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<b>(21) International Application Number:</b> PCT/US98/10295 <b>(22) International Filing Date:</b> 19 May 1998 (19.05.98) <b>(30) Priority Data:</b> 08/869,158 4 June 1997 (04.06.97) US <b>(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application</b> US 08/869,158 (CON) Filed on 4 June 1997 (04.06.97) <b>(71) Applicant (for all designated States except US):</b> MEDINOX, INC. [US/US]; Suite 201, 11575 Sorrento Valley Road, San Diego, CA 92121 (US). <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> LAI, Ching-San [US/US]; 209 Lolita Street, Encinitas, CA 92024 (US). <b>(74) Agent:</b> REITER, Stephen, E.; Gray Cary Ware & Freidenrich LLP, Suite 1600, 4365 Executive Drive, San Diego, CA 92121 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> CONJUGATES OF DITHIOCARBAMATES WITH PHARMACOLOGICALLY ACTIVE AGENTS AND USES THEREFOR		
<b>(57) Abstract</b> <p>In accordance with the present invention, there are provided conjugates of nitric oxide scavengers (e.g., dithiocarbamates, or "DC") and pharmacologically active agents (e.g., NSAIDs). Invention conjugates provide a new class of pharmacologically active agents (e.g., anti-inflammatory agents) which cause a much lower incidence of side-effects due to the protective effects imparted by modifying the pharmacologically active agents as described herein. In addition, invention conjugates are more effective than unmodified pharmacologically active agents because cells and tissues contacted by the pharmacologically active agent(s) are protected from the potentially damaging effects of nitric oxide overproduction induced thereby as a result of the co-production of nitric oxide scavenger (e.g., dithiocarbamate), in addition to free pharmacologically active agent, when invention conjugate is cleaved.</p>		

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Conjugates of Dithiocarbamates with Pharmacologically  
Active Agents and Uses Therefor

FIELD OF THE INVENTION

The present invention relates to novel conjugated forms of pharmacologically active agents, and methods for the preparation and use thereof. In a particular aspect of the invention, methods are provided for simultaneously  
5 treating a pathological condition with a pharmacologically active agent and reducing nitric oxide levels.

BACKGROUND OF THE INVENTION

Despite the advent of modern pharmaceutical  
10 technology, many drugs still possess untoward toxicities which often limit the therapeutic potential thereof. For example, although non-steroid anti-inflammatory drugs (NSAIDs) are a class of compounds which are widely used for the treatment of inflammation, pain and fever, NSAIDs  
15 (e.g., aspirin, ibuprofen and ketoprofen) can cause gastrointestinal ulcers, a side-effect that remains the major limitation to the use of NSAIDs (see, for example, J. L. Wallace, in Gastroenterol. 112:1000-1016 (1997); A. H. Soll et al., in Ann Intern Med. 114:307-319 (1991); and J.  
20 Bjarnason et al., in Gastroenterol. 104:1832-1847 (1993)).

There are two major ulcerogenic effects of NSAIDs: (1) topical irritant effects on the epithelium of the gastrointestinal tract and (2) suppression of gastrointestinal prostaglandin synthesis. In recent years,  
25 numerous strategies have been attempted to design and develop new NSAIDs that reduce the damage to the gastrointestinal tract. These efforts, however, have largely been unsuccessful. For example, enteric coating or slow-release formulations designed to reduce the topical

irritant properties of NSAIDs have been shown to be ineffective in terms of reducing the incidence of clinically significant side effects, including perforation and bleeding (see, for example, D. Y. Graham et al., in Clin. Pharmacol. Ther. 38:65-70 (1985); and J. L. Carson, et al., in Arch. Intern. Med., 147:1054-1059 (1987)).

It is well recognized that aspirin and other NSAIDs exert their pharmacological effects through the inhibition of cyclooxygenase (COX) enzymes, thereby blocking prostaglandin synthesis (see, for example, J. R. Van in Nature, 231:232-235 (1971)). There are two types of COX enzymes, namely COX-1 and COX-2. COX-1 is expressed constitutively in many tissues, including the stomach, kidney, and platelets, whereas COX-2 is expressed only at the site of inflammation (see, for example, S. Kargan et al. in Gastroenterol., 111:445-454 (1996)). The prostaglandins derived from COX-1 are responsible for many of the physiological effects, including maintenance of gastric mucosal integrity.

Many attempts have been made to develop NSAIDs that only inhibit COX-2, without impacting the activity of COX-1 (see, for example, J.A. Mitchell et al., in Proc. Natl. Acad. Sci. USA 90:11693-11697 (1993); and E.A. Meade et al., in J. Biol. Chem., 268:6610-6614 (1993)). There are at least two NSAIDs presently on the market (i.e., nabumetone and etodolac) that show marked selectivity for COX-2 (see, for example, E. A. Meade, supra.; and K. Glaser et al., in Eur. J. Pharmacol. 281:107-111 (1995)). These drugs appear to have reduced gastrointestinal toxicity relative to other NSAIDs on the market.

On the basis of encouraging clinical as well as experimental data, the development of highly selective COX-2 inhibitors appears to be a sound strategy to develop a new generation of anti-inflammatory drugs. However, the

physiological functions of COX-1 and COX-2 are not always well defined. Thus, there is a possibility that prostagladins produced as a result of COX-1 expression may also contribute to inflammation, pain and fever. On the  
5 other hand, prostagladins produced by COX-2 have been shown to play important physiological functions, including the initiation and maintenance of labor and in the regulation of bone resorption (see, for example, D. M. Slater et al., in *Am. J. Obstet. Gynecol.*, 172:77-82 (1995); and Y. Onoe  
10 et al., in *J. Immunol.* 156:758-764 (1996)), thus inhibition of this pathway may not always be beneficial. Considering these points, highly selective COX-2 inhibitors may produce additional side effects above and beyond those observed with standard NSAIDs, therefore such inhibitors may not be  
15 highly desirable.

Since anthracyclines such as adriamycin are commonly used antitumor agents, considerable efforts have also been made to develop strategies for reducing the acute and delayed cardiomyopathies induced by anthracyclines,  
20 while maintaining the therapeutic efficacy of these compounds. The molecular mechanism of cardiomyopathy is now attributed to the adriamycin-induced release of iron from intracellular iron proteins, resulting in the formation of an adriamycin-iron complex. The  
25 adriamycin-iron complex generates reactive oxygen species, causing the scission and condensation of DNA, peroxidation of phospholipid membranes, depletion of cellular reducing equivalents, interference with mitochondrial respiration, and disruption of cell calcium homeostasis (see, for  
30 example, Myers et al., in *Science* 197:165-167 (1977); and Gianni et al., in *Rev. Biochem. Toxicol.* 5:1-82 (1983)). In addition to cardiomyopathy, adriamycin administration causes cutaneous irritation and alopecia, mucositis (stomatitis and esophagitis), phlebosclerosis and  
35 hematologic toxicities and many other local and systemic toxicities.

Recently, ICRF-187 (i.e., dexrazoxane) has been demonstrated to be effective for the removal of iron from the anthracycline-iron complex, therefore preventing the cardiac toxicity in cancer patients receiving adriamycin chemotherapy (see, for example, Kolaric et al., in *Oncology* 52:251-5 (1995)). However, when chelated with iron, the iron-ICRF-187 complex per se is also very effective at promoting hydroxyl radical generation via the Fenton reaction, causing oxidative damage to tissues (see, for example, Thomas et al., in *Biochem. Pharmacol.*, 45:1967-72 (1993)). In addition, since ICRF-187 is a strong chelator (having a structure similar to EDTA), it chelates not only low-molecular-weight iron, but also chelates iron from transferrin and ferritin, as well as copper from ceruloplasmin, thus potentially affecting normal cellular iron metabolism.

Accordingly, there is still a need in the art for modified forms of NSAIDs, and other pharmacologically active agents, which cause a reduced incidence of side-effects, relative to the incidence of side-effects caused by such pharmacologically active agents as aspirin, ibuprofen, and the like.

#### BRIEF DESCRIPTION OF THE INVENTION

In accordance with the present invention, there are provided conjugates of physiologically compatible nitric oxide scavengers (e.g., dithiocarbamates (DC)) and pharmacologically active agents (e.g., NSAIDs). Invention conjugates provide a new class of pharmacologically active agents (e.g., anti-inflammatory agents) which cause a much lower incidence of side-effects due to the protective effects imparted by modifying the pharmacologically active agents as described herein.

Recent evidence has shown that NSAID administration up-regulates the expression of inducible nitric oxide synthase (see, for example, B.J.R. Whittle et al., in Br. J. Pharmacol., 116:2286-2290 (1995)).

5 Excessive nitric oxide produced from inducible nitric oxide synthase is known to contribute to the generation of mucosal damage (see, for example, S. J. Middleton et al., in Lancet 341:456-466 (1993); and M.J.S. Miller et al., in Scand. J. Gastroenterol., 264:11-16 (1993)). When chelated  
10 with iron (e.g., intracellular iron), nitric oxide scavengers (such as a dithiocarbamate-iron complex) becomes an effective nitric oxide scavenger which binds tightly to nitric oxide and reduces in vivo nitric oxide levels. It is now recognized that excessive nitric oxide production  
15 can induce the expression of COX-2, thereby enhancing the cascade of inflammatory reactions. Thus, scavenging NO by a nitric oxide scavenger (such as the dithiocarbamate-iron complex) could reduce the negative consequences brought about by excessive COX-2 levels, by reducing the expression  
20 of COX-2.

In summary, there are a number of advantages of conjugates according to the invention (e.g., DC-NSAID), including:

- (i) reduced topical irritant effects of NSAIDs,
- 25 (ii) enhanced tissue delivery of both drugs as a result of a decrease in net charges on the molecule, particularly for acidic NSAIDs such as aspirin, diclofenac and ibuprofen, thereby reducing the quantity of material which must be delivered to achieve an effective dosage,
- 30 (iii) chelating intracellular free iron ions, thereby preventing iron-related oxidative damage,
- (iv) inhibiting VCAM-1 expression, thereby blocking neutrophil adherence to the vascular endothelium induced by NSAID administration, and
- 35 (v) scavenging intracellular nitric oxide, thereby preventing the production of peroxynitrite, a

potent oxidant, and reducing the induction of COX-2 expression, which could induce further inflammatory response.

In another aspect of the invention, there are described bio-cleavable conjugates of a suitable nitric oxide scavenger (e.g., dithiocarbamate) and an anti-neoplastic agent (e.g., adriamycin, wherein the resulting conjugate is referred to as DC-adriamycin), which alleviate some of the toxicities associated with administration of anti-neoplastics such as adriamycin. There are a number of advantages of DC-adriamycin over adriamycin alone, including:

- (i) reducing cutaneous irritation and alopecia and vascular damage (because the conjugates are inactive until they have reached the intracellular site of action),
- (ii) chelating intracellular iron, thus reducing free radical-induced acute and delayed cardiomyopathies, and
- (iii) removing excessive nitric oxide produced from malignant and cancerous tissues.

#### DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, there are provided compounds comprising a suitable nitric oxide scavenger (e.g., a dithiocarbamate) covalently attached to a pharmacologically active agent.

As readily recognized by those of skill in the art, a variety of chemical entities can be used for scavenging nitric oxide, e.g., iron-chelating compounds such as dithiocarbamates, desferrioxamine (DF), ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTPA), hydroxypyridinones, pyridoxalisonicotinoylhydrazone (PIH), quercetin, 1,2-dimethyl-3-hydroxypyrid-4-one (LI), phytic



acid, dexrazoxane (ICRF-187), N,N- dibenzylethylene-diamine-N,N-diacetic acid (DBED), and the like.

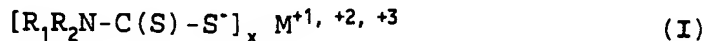
Other nitric oxide scavenging compounds contemplated for use herein include: 2-mercaptonicotinic  
5 acid, nitronyl nitroxide, nitric oxide chelotropes (i.e., compounds containing the 7,7,8,8-tetraalkyl-0-quinodimethane type moiety), dimercaptosuccinic acid, 2-phenyl-4,4,5,5-tetramethylimidazoline-1-oxyl 3-oxide (PTIO), carboxy-PTIO, phenyl-n-tert-butyl nitron, and other nitron derivatives,  
10 and the like.

Dithiocarbamates are sulfur-containing small molecules that are known heavy metal chelators (see, for example, F. W. Sunderman, in Ann. Clin. Lab. Sci., 8:259-69 (1978); and M. M. Jones and M. G. Cherian, in Toxicology,  
15 62:1-25 (1990)). Dithiocarbamates such as diethyl-dithiocarbamate have been used clinically in the treatment of nickel poisoning (see, for example, Sunderman, supra) and were used in clinical trials for the treatment of AIDS patients (see, for example, E. Reisinger et al., in Lancet,  
20 335:679 (1990)).

Dithiocarbamates such as pyrrolidine dithiocarbamate are potent inhibitors of nuclear factor kappa B in intact cells (see, for example, R. Schreck et al., in J. Exp. Med., 175:1181-1194 (1992)). In addition,  
25 nuclear factor kappa B has been shown to up-regulate the expression of cell adhesive molecules, including the vascular cell adhesive molecule 1 (VCAM-1; see, for example, M. F. Iademaro et al., in J. Biol. Chem., 267:16323-16329 (1992)). Endothelial expression of VCAM-1  
30 causes the adherence of neutrophils to the endothelium, an early event leading to inflammation and subsequent vascular damage and reduction of blood flow (see, for example, M. N. Oppenheimer et al., in J. Immunol., 147:42207-4210 (1991)). It has been recognized that NSAID administration increases

neutrophil adherence to the vascular endothelium in the gastric and mesenteric microcirculation (see, for example, J. L. Wallace et al., in *Gastroenterol.*, 105:1630-1636 (1993); and H. Asako et al., in *Am J. Physiol.*, 262:G903-G908 (1992)). Therefore, conjugates of NSAIDs with dithiocarbamate would block VCAM-1 expression, thereby avoiding the vascular problems associated with neutrophil adherence to the endothelium.

Suitable dithiocarbamate compounds contemplated for use in the practice of the present invention can be described with reference to generic structure I as follows:



wherein:

each of  $R_1$  and  $R_2$  is independently selected from a  $C_1$  up to  $C_{18}$  alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heterocyclic, substituted heterocyclic, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkylaryl, substituted alkylaryl, arylalkyl, substituted arylalkyl, arylalkenyl, substituted arylalkenyl, arylalkynyl, substituted arylalkynyl, aroyl, substituted aroyl, acyl, substituted acyl, or

$R_1$  and  $R_2$  cooperate to form a 5-, 6- or 7-membered ring including N,  $R_1$  and  $R_2$ , or

$R_1$  or  $R_2$  is a divalent moiety selected from the group consisting of alkylene, substituted alkylene, oxyalkylene, substituted oxyalkylene, alkenylene, substituted alkenylene, arylene, substituted arylene, alkarylene, substituted alkarylene, aralkylene and substituted aralkylene, wherein said divalent moiety serves as the

same substituent for two dithiocarbamate structures, thereby linking said structures together so as to form a bis(dithiocarbamate) species,

5       x is 1 or 2, and

M is a monovalent cation when x is 1, or M is a physiologically compatible divalent or trivalent transition metal cation when x is 2.

10       Presently preferred dithiocarbamate compounds having generic structure I are those wherein:

each of  $R_1$  and  $R_2$  = a  $C_1$  up to  $C_{12}$  alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl or substituted alkynyl, wherein the substituents are selected from carboxyl,  $-C(O)H$ , oxyacyl, phenol, phenoxy, pyridinyl, pyrrolidinyl, amino, amido, hydroxy, nitro or sulfonyl, or

20        $R_1$  and  $R_2$  cooperate to form a 5-, 6- or 7-membered ring including N,  $R_1$  and  $R_2$ , and

M =  $Fe^{+2}$  or  $Fe^{+3}$ .

Especially preferred dithiocarbamate compounds  
25   having generic structure I are those wherein:

$R_1$  is selected from a  $C_2$  up to  $C_8$  alkyl or substituted alkyl, wherein the substituents are selected from carboxyl, acetyl, pyridinyl, pyrrolidinyl, amino, amido, hydroxy or nitro, and

30        $R_2$  is selected from a  $C_1$  up to  $C_6$  alkyl or substituted alkyl, or

$R_2$  cooperates with  $R_1$  to form a 5-, 6- or 7-membered ring including N,  $R_2$  and  $R_1$ , and  
 $M = Fe^{+2}$ .

5           The presently most preferred dithiocarbamate compounds having generic structure I are those wherein:  
 $R_1$  is selected from a  $C_2$  up to  $C_8$  alkyl or substituted alkyl, wherein the substituents are selected from  
10           carboxyl, acetyl, amido or hydroxy, and  
 $R_2$  is selected from a  $C_1$  up to  $C_4$  alkyl or substituted alkyl, or  
 $R_2$  cooperates with  $R_1$  to form a 5- or 6-membered ring including N,  $R_2$  and  $R_1$ ,  
15           and  
 $M = Fe^{+2}$ .

When  $R_1$  and  $R_2$  cooperate to form a 5-, 6- or 7-membered ring, the combination of  $R_1$  and  $R_2$  can be a variety of saturated or unsaturated 4, 5 or 6 atom bridging species  
20           selected from alkenylene or -O-, -S-, -C(O)- and/or -N(R)- containing alkenylene moieties, wherein R is hydrogen or a lower alkyl moiety. Presently preferred dithiocarbamates wherein  $R_1$  and  $R_2$  cooperate to form a ring structure include pyrrolidine dithiocarbamate, proline dithiocarbamate,  
25           pyridine dithiocarbamate, pyridinium dithiocarbamate, pyrimidine dithiocarbamate, pyrroline dithiocarbamate, and the like.

Examples of presently preferred dithiocarbamates contemplated for use herein for the preparation of  
30           invention conjugates include sarcosine dithiocarbamate, iminodiacetic acid dithiocarbamate, diethyldithiocarbamate, diisopropyldithiocarbamate, sugar-linked dithiocarbamates (e.g., glucose-, lactose-, mannose-, fructose-linked

dithiocarbamates, and the like), pyrrolidine dithiocarbamate, proline dithiocarbamate, and the like.

Monovalent cations contemplated for incorporation into the above-described dithiocarbamate compounds include  
5  $H^+$ ,  $Na^+$ ,  $NH_4^+$ , tetraalkyl ammonium, and the like. Physiologically compatible divalent or trivalent transition metal cations contemplated for incorporation into the above-described dithiocarbamate compounds include charged forms of iron, cobalt, copper, manganese, ruthenium, or the  
10 like (e.g.,  $Fe^{+2}$ ,  $Fe^{+3}$ ,  $Co^{+2}$ ,  $Co^{+3}$ ,  $Cu^{+2}$ ,  $Mn^{+2}$ ,  $Mn^{+3}$  or  $Ru^{+3}$ ). In accordance with the present invention, the ratio of dithiocarbamate-species to counter-ion M can vary widely. Thus, dithiocarbamate-containing nitric oxide scavenger can be administered without any added metallic counter-ion  
15 (i.e.,  $M = H^+$ , or a transition metal cation to dithiocarbamate-species ratio of zero), with ratios of transition metal cation to dithiocarbamate-species up to about 1:2 (i.e., a 2:1 dithiocarbamate:transition metal cation complex) being suitable.

20 As employed herein, "substituted alkyl" comprises alkyl groups further bearing one or more substituents selected from hydroxy, alkoxy (of a lower alkyl group), mercapto (of a lower alkyl group), cycloalkyl, substituted cycloalkyl, heterocyclic, substituted heterocyclic, aryl,  
25 substituted aryl, heteroaryl, substituted heteroaryl, aryloxy, substituted aryloxy, halogen, trifluoromethyl, cyano, nitro, nitron, amino, amido,  $-C(O)H$ , acyl, oxyacyl, carboxyl, carbamate, sulfonyl, sulfonamide, sulfonyl, and the like.

30 As employed herein, "cycloalkyl" refers to cyclic ring-containing groups containing in the range of about 3 up to 8 carbon atoms, and "substituted cycloalkyl" refers to cycloalkyl groups further bearing one or more substituents as set forth above.

As employed herein, "alkenyl" refers to straight or branched chain hydrocarbyl groups having at least one carbon-carbon double bond, and having in the range of about 2 up to 12 carbon atoms, and "substituted alkenyl" refers to alkenyl groups further bearing one or more substituents as set forth above.

As employed herein, "alkynyl" refers to straight or branched chain hydrocarbyl groups having at least one carbon-carbon triple bond, and having in the range of about 2 up to 12 carbon atoms, and "substituted alkynyl" refers to alkynyl groups further bearing one or more substituents as set forth above.

As employed herein, "aryl" refers to aromatic groups having in the range of 6 up to 14 carbon atoms and "substituted aryl" refers to aryl groups further bearing one or more substituents as set forth above.

As employed herein, "alkylaryl" refers to alkyl-substituted aryl groups and "substituted alkylaryl" refers to alkylaryl groups further bearing one or more substituents as set forth above.

As employed herein, "arylalkyl" refers to aryl-substituted alkyl groups and "substituted arylalkyl" refers to arylalkyl groups further bearing one or more substituents as set forth above.

As employed herein, "arylalkenyl" refers to aryl-substituted alkenyl groups and "substituted arylalkenyl" refers to arylalkenyl groups further bearing one or more substituents as set forth above.

As employed herein, "arylalkynyl" refers to aryl-substituted alkynyl groups and "substituted arylalkynyl"

refers to arylalkynyl groups further bearing one or more substituents as set forth above.

As employed herein, "aroyl" refers to aryl-carbonyl species such as benzoyl and "substituted aroyl"  
5 refers to aroyl groups further bearing one or more substituents as set forth above.

As employed herein, "heterocyclic" refers to cyclic (i.e., ring-containing) groups containing one or more heteroatoms (e.g., N, O, S, or the like) as part of  
10 the ring structure, and having in the range of 3 up to 14 carbon atoms and "substituted heterocyclic" refers to heterocyclic groups further bearing one or more substituents as set forth above.

As employed herein, "acyl" refers to alkyl-  
15 carbonyl species.

As employed herein, "halogen" refers to fluoride, chloride, bromide or iodide atoms.

Diseases and conditions contemplated for treatment in accordance with the present invention include  
20 inflammatory and infectious diseases, such as, for example, septic shock, hemorrhagic shock, anaphylactic shock, toxic shock syndrome, ischemia, cerebral ischemia, administration of cytokines, overexpression of cytokines, ulcers, inflammatory bowel disease (e.g., ulcerative colitis or  
25 Crohn's disease), diabetes, arthritis, asthma, Alzheimer's disease, Parkinson's disease, multiple sclerosis, cirrhosis, allograft rejection, encephalomyelitis, meningitis, pancreatitis, peritonitis, vasculitis, lymphocytic choriomeningitis, glomerulonephritis, uveitis,  
30 ileitis, inflammation (e.g., liver inflammation, renal inflammation, and the like), burn, infection (including bacterial, viral, fungal and parasitic infections),

hemodialysis, chronic fatigue syndrome, stroke, cancers (e.g., breast, melanoma, carcinoma, and the like), cardiopulmonary bypass, ischemic/reperfusion injury, gastritis, adult respiratory distress syndrome, cachexia, 5 myocarditis, autoimmune disorders, eczema, psoriasis, heart failure, heart disease, atherosclerosis, dermatitis, urticaria, systemic lupus erythematosus, AIDA, AIDS dementia, chronic neurodegenerative disease, chronic pain, priapism, cystic fibrosis, amyotrophic lateral sclerosis, 10 schizophrenia, depression, premenstrual syndrome, anxiety, addiction, migraine, Huntington's disease, epilepsy, neurodegenerative disorders, gastrointestinal motility disorders, obesity, hyperphagia, solid tumors (e.g., neuroblastoma), malaria, hematologic cancers, 15 myelofibrosis, lung injury, graft-versus-host disease, head injury, CNS trauma, hepatitis, renal failure, liver disease (e.g., chronic hepatitis C), drug-induced lung injury (e.g., paraquat), myasthenia gravis (MG), ophthalmic diseases, post-angioplasty, restenosis, angina, coronary 20 artery disease, and the like.

Pharmacologically active agents contemplated for modification in accordance with the present invention include:

NSAIDs, such as acetaminophen (Tylenol, Datril, etc.), 25 aspirin, ibuprofen (Motrin, Advil, Rufen, others), choline magnesium salicylate (Triasate), choline salicylate (Anthropan), diclofenac (voltaren, cataflam), diflunisal (dolobid), etodolac (lodine), fenoprofen calcium (nalfon), 30 flurobiprofen (ansaid), indomethacin (indocin, indometh, others), ketoprofen (orudis, oruvail), ketorolac tromethamine (toradol), magnesium salicylate (Doan's, magan, mobidin, others), meclofenamate sodium (meclomen), mefenamic acid 35 (relafan), oxaprozin (daypro), piroxicam



(feldene), sodium salicylate, sulindac (clinoril), tolmetin (tolectin), meloxicam, nabumetone, naproxen, lornoxicam, nimesulide, indoprofen, remifenzone, salsalate, tiaprofenic acid, flosulide, and the like;

5 analgesics/antipyretics (e.g., aspirin, acetaminophen, ibuprofen, naproxen sodium, buprenorphine hydrochloride, propoxyphene hydrochloride, propoxyphene napsylate, meperidine hydrochloride, hydromorphone hydrochloride, morphine sulfate, 10 oxycodone hydrochloride, codeine phosphate, dihydrocodeine bitartrate, pentazocine hydrochloride, hydrocodone bitartrate, levorphanol tartrate, diflunisal, trolamine salicylate, nalbuphine hydrochloride, mefenamic acid, butorphanol tartrate, choline salicylate, 15 butalbital, phenyltoloxamine citrate, diphenhydramine citrate, methotrimeprazine, cinnamedrine hydrochloride, meprobamate, and the like);

20 sedatives/hypnotics (e.g., barbiturates (e.g., pentobarbital, pentobarbital sodium, secobarbital sodium), benzodiazapines (e.g., flurazepam hydrochloride, triazolam, tomazepam, midazolam 25 hydrochloride, and the like);

antianginal agents (e.g., beta-adrenergic blockers, calcium channel blockers (e.g., nifedipine, diltiazem hydrochloride, and the like), nitrates (e.g., nitroglycerin, isosorbide dinitrate, 30 pentaerythritol tetranitrate, erythrityl tetranitrate, and the like));

antianxiety agents (e.g., lorazepam, buspirone hydrochloride, prazepam, chlordiazepoxide hydrochloride, oxazepam, clorazepate dipotassium, 35 diazepam, hydroxyzine pamoate, hydroxyzine hydrochloride, alprazolam, droperidol, halazepam, chlormezanone, and the like);

- antidepressants (e.g., doxepin hydrochloride, amoxapine, trazodone hydrochloride, amitriptyline hydrochloride, maprotiline hydrochloride, phenelzine sulfate, desipramine hydrochloride, nortriptyline hydrochloride, tranlycypromine sulfate, fluoxetine hydrochloride, doxepin hydrochloride, imipramine hydrochloride, imipramine pamoate, nortriptyline, amitriptyline hydrochloride, isocarboxazid, desipramine hydrochloride, trimipramine maleate, protriptyline hydrochloride, and the like);
- antipsychotic agents (e.g., haloperidol, loxapine succinate, loxapine hydrochloride, thioridazine, thioridazine hydrochloride, thiothixene, fluphenazine hydrochloride, fluphenazine decanoate, fluphenazine enanthate, trifluoperazine hydrochloride, chlorpromazine hydrochloride, perphenazine, lithium citrate, prochlorperazine, and the like);
- antimanic agents (e.g., lithium carbonate),
- antiarrhythmics (e.g., bretylium tosylate, esmolol hydrochloride, verapamil hydrochloride, amiodarone, encainide hydrochloride, digoxin, digitoxin, mexiletine hydrochloride, disopyramide phosphate, procainamide hydrochloride, quinidine sulfate, quinidine gluconate, quinidine polygalacturonate, flecainide acetate, tocainide hydrochloride, lidocaine hydrochloride, and the like);
- antihypertensive drugs, such as diuretics (hydrochlorothiazide, chlorthalidone, metolazone, indapamide, furosemide, bumetanide, torsemide, triamterene, amiloride, spronolactone),
- beta-adrenergic blocking agents (acebutolol, atenolol, betaxolol, cartelol, labetalol, metoprolol, nadolol, penbutolol, pindolol, propranolol, timolol), angiotensin converting

- enzyme inhibitors (benazepril, captopril, enalapril, fosinopril, quinoapril, ramipril, losartan), calcium channel-blocking agents (diltiazem, verapamil, amlodipine, felodipine, 5 isradipine, nicardipine, nifedipine), alpha-adrenoceptor blocking agents, sympatholytics, and vasodilators (such as prazosin, terazosin, doxazosin, clonidine, guanabenz, guanfacine, methylodopa, guanethidine, 10 guanethidine monosulfate, reserpine, hydralazine, minoxidil, and the like), as well as agents such as trimethaphan camsylate, phenoxybenzamine hydrochloride, pargyline hydrochloride, deserpidine, diazoxide, rescinamine, sodium 15 nitroprusside, rauwolfia serpentina, alseroxylon, phentolamine mesylate, and the like;
- antihistamine/antipruritic drugs, such as ethanolamines (e.g., diphenhydramine, diphenhydramine hydrochloride, clemastine, clemastine fumarate, 20 and the like), ethylenediamines (e.g., brompheniramine, brompheniramine maleate, chlorpheniramine, chlorpheniramine maleate, dexchlorpheniramine maleate, triprolidine, triprolidine hydrochloride, and the like), 25 phenothiazines (e.g., promethazine), piperidines (e.g., hydroxyzine, hydroxyzine hydrochloride, terfenadine, astemizole, azatadine, azatadine maleate, and the like), cyproheptadine, cyproheptadine hydrochloride, loratidine, 30 carbinoxamine maleate, diphenylpyraline hydrochloride, phenindamine tartrate, tripelennamine hydrochloride, methdilazine hydrochloride, trimiprazine tartrate, and the like;
- 35 immunosuppressants, such as glucocorticoids (methylprednisolone), myelin basic protein (e.g., 7-capaxone), anti-Fc receptor monoclonal

antibodies, hydroorotate dehydrogenase inhibitor, anti-IL2 monoclonal antibodies (e.g., CHI-621 and dacliximab), buspirone, castanospermine, CD-59 (complement factor inhibitor), 5-lipoxygenase inhibitor (e.g., CMI-392), phosphatidic acid synthesis antagonists, ebselen, edelfosine, enlimomab, galaptin, platelet activating factor antagonists, selectin antagonists (e.g., ICAM-4), interleukin-10 agonist, macrocyclic lactone, methoxatone, mizoribine, OX-19, peptigen agents, PG-27, protein kinase C inhibitors, phosphodiesterase IV inhibitor, single chain antigen binding proteins, complement factor inhibitor, sialophorin, sirolimus, spirocyclic lactams, 5-hydroxytryptamine antagonist, anti-TCR monoclonal antibodies, CD5 gelonin and TOK-8801, and the like;

antimetabolite cytotoxics (azathioprine, cyclophosphamide), C5a release inhibitor, benzydamine, peldesine, pentostatin, SDZ-ASM-981, thalidomide, benzoporphyrin derivatives, arachidonate antagonists (e.g., halometasone, halobetasol propionate), corticosteroid (clobetasol propionate), growth hormone antagonists (octapeptide somatostatin analogue, lanreotide, angiopeptin and dermopeptin), thymopentin, and the like;

neuroprotective agents, such as  $\alpha$ -adrenoreceptor antagonist (i.e.,  $\alpha$ -dihydroergocryptine), NMDA antagonists (e.g., 5,6,7-tichloro-THQTQ, remacemide, 2-piperazinecarboxylic acid, N-indologlycinamide derivatives, spiro[benzo(b)thiophen-4(5H) derivatives, CP-101606, eliprodil, dexamabinol, GV-150526, L-695902, L-701324, amantadine derivatives, dizocilpine, benzomorphan derivatives, aptiganel, (S)- $\alpha$ -phenyl-2-pyridine ethanamide dihydrochloride and 1-amino-

cyclopentanecarboxylic acid), sodium channel antagonists (e.g., 619C89), glycine antagonists (e.g., glystasins), calcium channel antagonists (e.g., 3,5-pyridinedicarboxylic acid derivatives, conopeptides, 1-piperazineethanol, thieno[2,3-b]pyridine-5-carboxylic acid derivatives, NS-3034, nilvadipine, nisoldipine, tirilazad mesylate, 2H-1-enzopyran-6-ol, nitron spin traps, iacidipine, iomeerzine hydrochloride, lemildipine, lifarizine, CPC-304, efonidipine, F-0401, piperazine derivatives), calpain inhibitors, fibrinogen antagonists (e.g., ancrod), integrin antagonists (e.g., antegren), thromboxane A<sub>2</sub> antagonist (e.g., 9H-carbazole-9-propanoic acid derivatives, 5-Heptenoic acid derivatives and 1-azulenesulfonic acid derivatives), brain-derived neurotropic factor, adrenergic transmitter uptake inhibitor (e.g., 1-butanamine), endothelin A receptor antagonists (e.g., benzenesulfonamide derivatives, GABA A receptor antagonists (e.g., triazolopyrimidine derivatives and cyclohexaneacetic acid derivatives), GPIIb IIIa receptor antagonists (e.g., C68-22), platelet aggregation antagonist (e.g., 2(1H)-quinolinone derivatives, 1H-pyrrole-1-acetic acid derivatives and coumadin), Factor Xa inhibitor, CPC-211, corticotropin releasing factor agonist, thrombin inhibitor (e.g., cothrombins, fraxiparine, dermatan sulfate and heparinoid), dotarizine, intracellular calcium chelators (e.g., BAPTA derivatives), radical formation antagonists (EPC-K1, 3-pyridinecarboxamide derivatives, superoxide dismutase, raxofelast, lubeluzole, 3H-pyrazol-3-one derivatives, kynurenic acid derivatives, homopiperazine derivatives, and

polynitroxyl albumin), protein kinase inhibitors (e.g., 1H-1,4-diazepine), nerve growth agonist (e.g., floor plate factor-5), glutamate antagonist (e.g., cyclohexanepropanoic acid, riluzole, NS-409 and acetamide derivatives), lipid peroxidase inhibitor (e.g., 2,5-cyclohexadiene-1,4-dione derivatives), sigma receptor agonist (e.g., cyclopropanemethanamine derivatives and SA-4503), thyrotropin releasing hormone agonist (e.g., JTP-2942, L-prolinamide and posatirelin), prolyl endopeptidase inhibitor, monosialoganglioside GM1, proteolytic enzyme inhibitor (e.g., nafamostat), neutrophil inhibitory factor, platelet activating factor antagonist (e.g., nupafant), monoamine oxidase B inhibitor (e.g., parafluoroselegiline and benzonitrile derivatives), PARS inhibitors, Angiotensin I converting enzyme inhibitor (e.g., perindopril and ramipril), acetylcholine agonist (e.g., pramiracetam), protein synthesis antagonist (e.g., procysteine), phosphodiesterase inhibitor (e.g., propentofylline), opioid kappa receptor agonist (e.g., 10H-phenothiazine-2-carboxamine derivatives), complement factor inhibitor (sCRI fragments), somatomedin-1, carnitine acetyltransferase stimulant (e.g., acetylcarnitine), and the like;

T cell inhibitors such as synthetic leucocyte antigen derived peptides, interleukin-1 receptor antagonist, MG/AnergiX, anti-CD3 monoclonal antibodies, anti-CD23 monoclonal antibodies, anti-CD28 antibodies, anti-CD2 monoclonal antibodies, CD4 antagonists, anti-E selectin antibodies, MHC inhibitors, monogens, mycophenolate mofetil, LRA-1 inhibitors, selectin inhibitors, and the like;

antimigraine agents, such as MK-462, 324C91, Phytomedicine, (S)-fluoxetine, calcium channel antagonists (e.g., nimodipine/Nimotop, flunarizine, dotarizine/FI-6026, iomerizine HCL/KB-2796, CPC-304, and CPC-317),  $\alpha$ -dihydroergocryptine, 5-HT<sub>1</sub> agonists, (e.g., Sumatriptan/Imitrex, Imigran, GR-85548, 311C, and GR-127607), 5-HT<sub>1D</sub> agonists, 5-HT<sub>1A</sub> antagonists, 5-HT<sub>1B</sub> antagonists (e.g., CP-93129), 5-HT<sub>1D</sub> antagonists (e.g., 1H-indole-5-ethanesulfonamide derivatives and 1H-indole-5-methanesulfonamide), 5-HT<sub>1D</sub> receptor cloned (e.g., 5-HT<sub>1D</sub> agents), 2-thiophenecarboxamide, 3-piperidinamine, diclofenac potassium, dihydroergotamine (e.g., DHE 45°), ergotamine tartrate, dolasetron mesilate, dotarizine, flupirtine, histamine-H<sub>3</sub> receptor agonist, indobufen, 1-azulenesulfonic acid derivatives, cholinesterase inhibitors, (e.g., S-9977), bradykinin antagonists, nitric oxide reductase inhibitors (e.g., BN-52296), nitric oxide receptor antagonists, substance P antagonists (e.g., Capsaicin/Nasocap), endopeptidase inhibitors (e.g., neutral endopeptidase, cloned), piperazine derivatives, neurokinin 1 antagonists, metergoline, dopamine D<sub>2</sub> antagonist (e.g., metoclopramide + lysine acetyl), enkephalinase inhibitors (e.g., neutral endopeptidase), 5-HT<sub>2</sub> antagonists (e.g., LY-053857), 5-HT<sub>3</sub> antagonists (e.g., Dolasetron mesilate/MDL-73147, and 4H-carbazol-4-one derivatives), tenosal, tolfenamic acid, cyclooxygenase inhibitors (e.g., carbasalate/carbaspirin calcium, and tenosal/MR-Y134), alpha adrenoreceptor antagonists (e.g., arotinolol, and dihydroergocryptine), opioid agonists (e.g., flupirtine/D-9998), beta adrenergic antagonists

(e.g., propranolol), valproate semisodium, propranolol hydrochloride, isometheptene mucate, dichloralphenazone, and the like;

antiarthritic agents, such as anti-CD4 monoclonal antibodies, phospholipase A1 inhibitor, loteprednol, tobramycin, combinations of loteprednol and tobramycin, salnacedin, amiprilose, anakinra, anergiX, anti-B7 antibody, anti-CD3H, anti-gp39, anti-MHC MAbs, antirheumatic peptides, anti-Tac(Fv)-PE40, AP-1 inhibitors, AR-324, purine nucleotide phosphorylase inhibitors (e.g., BCX-5), bindarit, CD2 antagonist (e.g., BTI-322), campath-1H, CD4 antagonist (e.g., CE9.1 and SB-210396), tumor necrosis factor antagonist (e.g., p80 TNFR, rhTNFbp, peptide T, CentTNF, thalidomide, CDP-571 and TBP-1), cobra venom factor, interleukin 1a agonist (e.g., cytogenin), interleukin 2 receptor antagonist (e.g., dacliximab), ICAM 1 antagonist (e.g., enlimomab), interleukin 1 beta converting enzyme inhibitors (e.g., ICE-inhibitors), interferons (e.g., thymocartin), interleukin-10, interleukin-13, interleukin 1 antagonist (e.g., SR-31747 and TJ-114), interleukin-2 antagonist (e.g., sirolimus), phospholipase C inhibitor, neurokinin 1 antagonist (e.g., L-733060), laflunimus, leflunomide, leucotriene antagonists, levamisole, LFA3TIP, macrocyclic lactone, MHC class II inhibitors, mizoribine, mycophenolate mofetil, NF $\kappa$ B inhibitors, oncolysin CD6, peldesine, pidotimod, PKC-RACK inhibitors, PNP inhibitors, reumacon, CD28 antagonist, roquinimex, RWJ-50271, subreum, T7 vector, tacrolimus, VLA antagonist (e.g., TBC-772), transforming growth factor beta agonist, methionine synthase inhibitors (e.g., vitamin B12 antagonist), adenosine A2 receptor agonist (e.g.,



YT-146), CD5 antagonist (e.g., zolimomab),  
5-lipoxygenase inhibitor (e.g., zileuton,  
tenidap, and ABT-761), cyclooxygenase inhibitor  
(e.g., tenoxicam, talmetacin, piroxicam,  
5 piroxicam cinnamate, oxaprozin, NXTHIO, ML-3000,  
mofezolac, nabumetone, flurbiprofen, aceclofenac,  
diclofenac, and dexibuprofen), metalloproteinase  
inhibitor (e.g., XR-168, TNF convertase  
inhibitors, GI-155704A, AG-3340 and BB-2983),  
10 nitric oxide synthase inhibitors (i.e., ARL-16556),  
phospholipase A2 inhibitor (e.g., ARL-67974),  
selectin antagonist (e.g., CAM inhibitors),  
leucotriene B4 antagonist (e.g., CGS-25019C),  
collagenase inhibitor (e.g., GR-129574A),  
15 cyclooxygenase 2 inhibitor (e.g., meloxicam),  
thromboxane synthase inhibitor (e.g., curcumin),  
cysteine protease inhibitor (e.g., GR-373),  
metalloproteinase inhibitor (D-5410), lipocortins  
synthesis agonist (e.g., rimexolone,  
20 predonisolone 21-farnesylate, HYC-141, and  
deflazacort), chelating agent (diacerein),  
elastase inhibitors, DNA directed RNA polymerase  
inhibitor (e.g., estrogens), oxygen radical  
formation antagonist (e.g., glucosamine sulfate),  
25 thrombin inhibitors (e.g., GS-522), collagen  
inhibitors (e.g., halofuginone), hyaluronic acid  
agonist (e.g., NRD-101, hylan, Dispasan, and  
Hyalart), nitric oxide antagonists (e.g.,  
hydroxocobalamin), stromelysin inhibitors (e.g.,  
30 L-758354), prostaglandin E1 agonist (e.g.,  
misoprostol, and misoprostol+diclofenac),  
dihydrofolate reductase inhibitor (e.g.,  
trimetrexate, and MX-68), opioid antagonist  
(e.g., nalmeffene), corticotropin releasing factor  
35 antagonist (e.g., NBI-103, and NBI-104),  
proteolytic enzyme inhibitor (e.g., protease  
nexin-1, and NCY-2010), bradykinin antagonist

- (e.g., tachykinin antagonists, and NPC-17731), growth hormone antagonist (e.g., octreotide), phosphodiesterase IV inhibitor (e.g., PDEIV inhibitors), gelatinase inhibitor (e.g., REGA-3G12), free radical scavengers (e.g., SIDR-1026), prostaglandin synthase inhibitors (e.g., sulfasalazine), phenylbutazone, penicillamine, salsalate, azathioprine, indomethacin, meclofenamate sodium, gold sodium thiomalate, ketoprofen, auranofin, aurothioglucose, tolmetin sodium, and the like; antigout agents (e.g., colchicine, allopurinol, and the like); anticoagulants (e.g., heparin, heparin sodium, warfarin sodium, and the like); thrombolytic agents (e.g., urokinase, streptokinase, alteplase, and the like); antifibrinolytic agents (e.g., aminocaproic acid); hemorheologic agents (e.g., pentoxifylline); antiplatelet agents (e.g., aspirin, empirin, ascriptin, and the like); anticonvulsants (e.g., valproic acid, divalproate sodium, phenytoin, phenytoin sodium, clonazepam, primidone, phenobarbital, phenobarbital sodium, carbamazepine, amobarbital sodium, methsuximide, metharbital, mephobarbital, mephentyoin, phensuximide, paramethadione, ethotoin, phenacemide, secobarbital sodium, clorazepate dipotassium, trimethadione, and the like); agents useful for calcium regulation (e.g., calcitonin, parathyroid hormone, and the like); antibacterial agents (e.g., amikacin sulfate, aztreonam, chloramphenicol, chloramphenicol palmitate, chloramphenicol sodium succinate, ciprofloxacin hydrochloride, clindamycin hydrochloride, clindamycin palmitate, clindamycin phosphate, metronidazole, metronidazole hydrochloride,

- gentamicin sulfate, lincomycin hydrochloride, tobramycin sulfate, vancomycin hydrochloride, polymyxin B sulfate, colistimethate sodium, colistin sulfate, and the like);
- 5 antifungal agents (e.g., griseofulvin, keloconazole, and the like);
- antiviral agents (e.g., interferon gamma, zidovudine, amantadine hydrochloride, ribavirin, acyclovir, and the like);
- 10 antimicrobials (e.g., cephalosporins (e.g., cefazolin sodium, cephadrine, cefaclor, cephalirin sodium, ceftizoxime sodium, cefoperazone sodium, cefotetan disodium, cefutaxime azotil, cefotaxime sodium, cefadroxil monohydrate, ceftazidime,
- 15 cephalixin, cephalothin sodium, cephalixin hydrochloride monohydrate, cefamandole nafate, cefoxitin sodium, cefonicid sodium, ceforanide, ceftriaxone sodium, ceftazidime, cefadroxil, cephadrine, cefuroxime sodium, and the like),
- 20 penicillins (e.g., ampicillin, amoxicillin, penicillin G benzathine, cyclacillin, ampicillin sodium, penicillin G potassium, penicillin V potassium, piperacillin sodium, oxacillin sodium, bacampicillin hydrochloride, cloxacillin sodium,
- 25 ticarcillin disodium, azlocillin sodium, carbenicillin indanyl sodium, penicillin G potassium, penicillin G procaine, methicillin sodium, nafcillin sodium, and the like), erythromycins (e.g., erythromycin ethylsuccinate,
- 30 erythromycin, erythromycin estolate, erythromycin lactobionate, erythromycin stearate, erythromycin ethylsuccinate, and the like), tetracyclines (e.g., tetracycline hydrochloride, doxycycline hyclate, minocycline hydrochloride, and the
- 35 like), and the like);
- antioxidants (e.g., N-acetylcysteine, Vitamin A, Vitamin C, Vitamin E,  $\beta$ -carotene, EUK-8, flavonoids,

glutathione,  $\alpha$ -lipoic acid, melatonin, retinols, and the like);

anti-infectives (e.g., miconazole, vidarabine, inosine, pranobex, vidarabine, inosine prabonex, cefpimizole sodium), fradiomycin, and the like);

5 bronchodialators (e.g., sympathomimetics (e.g., epinephrine hydrochloride, metaproterenol sulfate, terbutaline sulfate, isoetharine, isoetharine mesylate, isoetharine hydrochloride, albuterol sulfate, albuterol, bitolterol, mesylate

10 isoproterenol hydrochloride, terbutaline sulfate, epinephrine bitartrate, metaproterenol sulfate, epinephrine, epinephrine bitartrate), anticholinergic agents (e.g., ipratropium bromide), xanthines (e.g., aminophylline, dyphylline, metaproterenol sulfate, aminophylline), mast cell stabilizers (e.g., cromolyn sodium), inhalant corticosteroids (e.g., flurisolide beclomethasone dipropionate, beclomethasone dipropionate monohydrate),

15 salbutamol, beclomethasone dipropionate (BDP), ipratropium bromide, budesonide, ketotifen, salmeterol, xinafoate, terbutaline sulfate, triamcinolone, theophylline, nedocromil sodium, metaproterenol sulfate, albuterol, flunisolide, and the like);

hormones (e.g., androgens (e.g., danazol, testosterone cypionate, fluoxymesterone, ethyltestosterone, testosterone enanthate, methyltestosterone,

20 fluoxymesterone, testosterone cypionate), estrogens (e.g., estradiol, estropipate, conjugated estrogens), progestins (e.g., methoxyprogesterone acetate, norethindrone acetate), corticosteroids (e.g., triamcinolone, betamethasone, betamethasone sodium phosphate,

25 dexamethasone, dexamethasone sodium phosphate, dexamethasone acetate, prednisone,

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5 methylprednisolone acetate suspension,  
triamcinolone acetonide, methylprednisolone,  
prednisolone sodium phosphate methylprednisolone  
sodium succinate, hydrocortisone sodium  
succinate, methylprednisolone sodium succinate,  
triamcinolone hexacetonide, hydrocortisone,  
hydrocortisone cypionate, prednisolone,  
fluorocortisone acetate, paramethasone acetate,  
prednisolone tebutate, prednisolone acetate,  
10 prednisolone sodium phosphate, hydrocortisone  
sodium succinate, and the like), thyroid hormones  
(e.g., levothyroxine sodium) and the like), and  
the like;

hypoglycemic agents (e.g., human insulin, purified beef  
15 insulin, purified pork insulin, glyburide,  
chlorpropamide, glipizide, tolbutamide,  
tolazamide, and the like);

hypolipidemic agents (e.g., clofibrate, dextrothyroxine  
sodium, probucol, lovastatin, niacin, and the  
20 like);

proteins (e.g., DNase, alginase, superoxide dismutase,  
lipase, and the like);

nucleic acids (e.g., sense or anti-sense nucleic acids  
encoding any therapeutically active protein,  
25 including the proteins described herein, and the  
like);

agents useful for erythropoiesis stimulation (e.g.,  
erythropoietin);

antiulcer/antireflux agents (e.g., famotidine, cimetidine,  
30 ranitidine hydrochloride, and the like);

antinauseants/antiemetics (e.g., meclizine hydrochloride,  
nabilone, prochlorperazine, dimenhydrinate,  
promethazine hydrochloride, thiethylperazine,  
scopolamine, and the like);

35 septic shock agents, such as angiogenesis inhibitors  
(OLX-514), bradykinin antagonists (e.g., CP-0502,  
and NPC-17731), complement factor inhibitors

(e.g., C3 convertase inhibitor), C5a release inhibitors (e.g., CAB-2.1), dopamine agonists (e.g., dopexamine), elastase inhibitors (e.g., ONO-5046), E selectin antagonists (e.g., CY-1787), farnesyltransferase inhibitors (RBE limonene), immunostimulants (e.g., CGP-19835A, lipid A vaccine, edobacomab, nebacumab, StaphGAM, and diabodies), immunosuppressants (e.g., CytoTAB, and transcyclopentanyl purine analogues), interleukin 1 antagonists (e.g., interleukin 1 receptors), interleukin 1 receptor antagonists (e.g., anakinra), interleukin 1b antagonists (e.g., interleukin-1 $\beta$ ), interleukin 1beta converting enzyme inhibitors (e.g., ICE-inhibitors), interleukin 8 antagonists (e.g., IL-8 receptor), interleukin 13 agonists (e.g., intereleukin-13), ITF-1697, lipase clearing factor inhibitors (e.g., SC-59735), membrane permeability enhancers (e.g., Bactericidal Permeability Increasing protein/BPI), nitric oxide antagonists (e.g., hydroxocobalamin), nitric oxide synthase inhibitors (e.g., L-NMMA, and  $\alpha$ -methyl-N-delta-iminoethyl-ornithine), P2 receptor stimulants (e.g., ATP analogues), phosphatidic acid synthesis antagonists (e.g., lisofylline), phospholipase A2 inhibitors (e.g., S-448, acylpyrrole-alkanoic acid derivatives, and indoleacetic acid derivatives), platelet activating factor antagonists (e.g., ABT-299, TCV-309, SM-12502, (2RS,4R)-3-(2-(3-pyridinyl)-thiazolidin-4-oyl)indoles, UR-12670, and E-5880), prostacyclin agonists (e.g., taprostene), prostaglandin E1 agonists (e.g., TLC C-53), protein kinase inhibitors (e.g., SB-203580), protein kinase C inhibitors, protein synthesis antagonists (e.g., procysteine), proteolytic enzyme inhibitors (e.g., nafamostat),

SDZ-PMX-622, selectin antagonists (e.g., sulfated glycolipid cell adhesion inhibitors), thrombin inhibitors (e.g., GS-522), TNF receptor-Ig, tumor necrosis factor antagonists (e.g., anti-TNF MABs, MAK-195F, TBP-I, Yeda, rhTNFbp, and CDP-571), tumor necrosis factor alpha antagonists (e.g., E-5531), and the like;

multiple sclerosis agents, such as 4-aminopyridine, 15+deoxyspergualin, ACTH, amantadine, antibody adjuvants (e.g., poly-ICLC, and poly-IC+poly-L-lysine+carboxymethylcellulose), anti-cytokine MAb (CDP-835), anti-inflammatory (e.g., CY-1787, and CY-1503), anti-selectin MAB (e.g., CY-1787), anti-TCR MAB (e.g., NBI-114, NBI-115, and NBI-116), baclofen, bethanechol chloride, carbamazepine, carbohydrate drugs (e.g., CY-1503), clonazepam, CNS and immune system function modulators (e.g., NBI-106, and NBI-107), cyclophosphamide, cyclosporine A, cytokines (e.g., IFN- $\alpha$ , alfaferone, IFN- $\beta$  1b, betaseron, TGF- $\beta$ 2, PEG-TGF- $\beta$ 2, betakine, IFN- $\beta$ /Rebif, frone, interferon- $\beta$ , and IFN- $\beta$ ), CD4+T cell inhibitors (e.g., AnergiX), CD28 antagonists (e.g., B7-1, B7-2, and CD28), direct cytotoxicity therapies (e.g., benzoporphyrin derivative (BPD)), FK-506, growth factors (e.g., glial growth factor, GGF, nerve growth factors, TGF- $\beta$ 2, PEG-TGF- $\beta$ 2, and betakine), humanized MAB (e.g., anti-IFN- $\gamma$ MAB, smart anti-IFN- $\gamma$ MAB, anti-Tac antibody, and smart anti-Tac antibody), humanized anti-CD4 MAB (e.g., anti-CD4 MAB, centara), hydrolase stimulants (e.g., castanospermine), IFN- $\alpha$ , IFN- $\gamma$  antagonist (e.g., anti-IFN- $\gamma$  MAB, and smart anti-IFN- $\gamma$  MAB), IL-2 antagonists (e.g., tacrolimus, FK-506, FR-900506, Fujimycin, Prograf, IL-2 fusion toxin, and DAB<sub>389</sub>IL-2), IL-4 antagonists (e.g., IL-4 fusion toxin, and

DAB<sub>389</sub>IL-4), immune-mediated neuronal damage inhibitors (e.g., NBI-114, NBI-115, and NBI-116), immunoglobins, immunostimulants (e.g., poly-ICLC, edelfosine, ALP, ET-18-OCH<sub>3</sub>, ET-18-OME, NSC-24, and poly-IC+poly-L-lysine+carboxymethyl-cellulose), immunosuppressants (e.g., azathioprine, AI-100 animal protein, rDNA human protein AI-101, peptide, AI-102, castanospermine, tacrolimus, FK-506, FR-900506, Fujimycin, Prograf, anti-leukointegrin MAb, Hu23F2G, primatized anti-CD4 antibody, CE9.1, Galaptin 14-1, GL14-1, Lectin-1, recombinant IML-1, linomide, roquinimex, LS-2616, transcyclo-pentanyl purine analogs, MS-6044, spanidin, 15-deoxyspergualin, deoxyspurgiline, gusperimus HCL, NSC-356894, NKT-01, TCR, CD3/Ti, cyclosporine, OL-27-400, SandImmune, Human IL-10, monogens, anti-TCR MAbs, TCAR MAbs, Monogen TM19, Monogen TM27, Monogen TM29, Monogen TM31, peptigen TP12, anti-CD4 MAb, cantara, immunophilins, VX-10367, VX-10393, VX-10428, synthetic basic copolymer of amino acids, copolymer-1, COP-1, T lymphocyte immunofusion (TIF) protein, and cyclophosphamide), integrin antagonists (e.g., anti-integrin (cell adhesion molecule  $\alpha 4\beta 1$  integrin) MAbs, AN-100225, and AN-100226), interferon agonists (e.g., poly-ICLC, and poly-IC+poly-L-lysine+carboxymethyl-cellulose), interferon- $\beta$ -1b, isoprinosine, IV methylprednisolone, macrolides (e.g., tacrolimus, FK-506, FR-900506, Fujimycin, and Prograf), MAO B inhibitors (e.g., selegiline, and Parkinyl), methotrexate, mitoxantrone, muscle relaxants (e.g., RGH-5002), muscarinic antagonists (e.g., RGH-5002), neurosteroids (e.g., NBI-106, and NBI-107), octapeptides (e.g., peptide T), oxybutinin chloride, oxygen free radical



antagonists (e.g., tetrandrine, biobenzylisoquinoline alkaloid), peptide agonists (e.g., peptide T), phenoxybenzamine, phospholipase C inhibitors (e.g., edelfosine, ALP, ET-18-OCH<sub>3</sub>, ET-18-OME, NSC-24), photodynamic therapies (e.g., benzoporphyrin derivative (BPD)), plasmapheresis, platelet activating factor antagonists (e.g., ginkgolide B, and BN-52021), potassium channel antagonists (e.g., aminodиаquine, and EL-970), propranolol, prostaglandin synthase inhibitors (e.g., sulfasalazine, salazosulfa-pyridine, PJ-306, SI-88, azulfidine, salazopyrin), protease antagonists (e.g., ginkgolide B, and BN-52021), recombinant soluble IL-1 receptors, spergualin analogs (e.g., spanidin, 15-deoxyspergualin, deoxyspurgiline, gusperimus HCl, NSC-356894, NKT-01), TCR peptide decoys (e.g., NBI-114, NBI-115, and NBI-116), TCR peptidomimetic decoys (e.g., NBI-114, NBI-115, and NBI-116), TCR peptide vaccines (e.g., AI-208 (V $\beta$ 6.2/6.5 phenotype)), selectin antagonists (e.g., lectin-1, and recombinant IML-1), soluble TNF receptor I, TCARs (e.g., TCR, CD3/Ti, and peptigen TP12), TNF antagonists (e.g., thalidomide, and TNF inhibitors), tricyclic antidepressants, and the like;

organ transplantation agents, such as anti-CD25 MABs, anti-Tac antibodies, anti-TNF MAB (e.g., CDP571), apoptosin, azathioprimines (e.g., imuran), BCX-34, CA3, CD28, complement inhibiting factors (e.g., CD59), CTLA4Ig, cyclosporines (e.g., CsA), FK-506/rapamycin binding proteins (FKBP), glucocorticoids, humanized version of OKT3 (e.g., huOKT3-185), mycophenolate mofetil, hydroorotate dehydrogenase inhibitors (e.g., Brequinar), orthoclone OKT3 (e.g., IgG2a anti-T cell murine

monoclonal antibody, and muromonab-CD3), rapamycins (e.g., AY-22989), and streptomyces isolates (e.g., FR-900520, and FR-900523), and the like;

- 5 systemic lupus erythematosus (SLE) agents, such as androgen-derived steroids (e.g., Org-4094), anti-CD4 humanized antibodies, anti-DNA/V-88, anti-idiotypic murine MAb (e.g., anti-idiotypic antibody to 3E10/MAB1C7), CD2 antagonists (e.g.,
- 10 CD2), complement inhibitors (e.g., recombinant MCP-based complement inhibitors), cyclosporines (e.g., Sandimmune, cyclosporine analog, OG-37325, cyclosporin-G, and NVal-CyA), cytokines (e.g., IL-4 fusion toxin), cytokine receptor antagonists
- 15 (e.g., immunomodulatory cytokines), E-selectin antagonists (e.g., anti-ELAM, and CY-1787), FK506/tacrolimus (e.g., Prograf), hypercalcemic agents (e.g., KH-1060), IFN- $\gamma$  antagonists (e.g., anti-IFN- $\gamma$  MAb, and smart anti-IFN- $\gamma$  MAb), IL-1 $\beta$
- 20 converting enzyme inhibitors (ICE), IL-2 produced by E. coli (e.g., celmoleukin, IL-2, TGP-3, and Celeuk), immunoglobulins (e.g., anti-ELAM, CY-1788, and humanized CY-1787), immunostimulants (e.g., thymotrigan, RGH-0205, and TP3),
- 25 immunosuppressants (e.g., Rapamycin, AY-22989, NSC-226080, NSC-606698, anti-CD4, T-cell inhibitor, anti-tac MAb, smart anti-tac MAb, Migis (membrane immunoglobulin-isotope specific) antibodies, SM-8849, immunophilins, VX-10367,
- 30 VX-10393, VX-10428, mycophenolate mofetil, ME-MPA, RS-61444, cyclosporine, OL-27-400, Sandimmune, IL-4 fusion toxin, trypanosomal inhibitory factor (TIF), T-cell receptor, CD3/Ti, Org-4094, anti-TBM, CP 17193,
- 35 Leflunomide/A-77-1726, ELAM-1, Anergix, Spanidin, 15-deoxyspergualin, deoxyspergiline, gusperimus hydrochloride, NSC-356894, NKT-01, Roquinimex,

LS-2616, linomide, LJP-394, and CD-59 antigen), immunotoxins (e.g., Zolimomab aritox, xmmly-h65-rta, xomazyme-lym/CD5-Plus, OrthoZyme-CD5+, XomaZyme-H65-rta, Xomazyme-CD5 Plus), intravenous immunoglobulins (e.g., IVIG), integrin antagonists (e.g., integrin blockers), Migis™ antibodies, monoclonal antibody therapeutics, murine MAb (e.g., anti-SLE vaccine, and MAb 3E10), primatized anti-CD4 antibodies (e.g., CE9.1), protease inhibitors (e.g., matrix metalloprotease (MMP) inhibitors, and stromelysin), protein synthesis antagonists (e.g., anti-CD6-bR, anti-T12-bR, and oncolysin CD6), purine nucleoside phosphorylase inhibitors (e.g., BCX-25, and BCX-14), selectin antagonists (e.g., CY1503, and Cylexin), spergualin analogues (e.g., Spanidin, 15-deoxyspergualin, deoxyspurgiline, gusperimus hydrochloride, NSC-356894, and NKT-01), T cell inhibitors (e.g., AnergiX), tumor necrosis factor (TNF) antagonists, and the like;

Alzheimer's disease agents, such as ACh release enhancers (e.g., T-588 (benzothiophene derivative)), acetylcholine release stimulants (e.g., DUP-996 and analogues), AMPA agonists (e.g., AMAlex, and Isoxazole compound series), AMPA GluR agonist (e.g., IDRA-21 [7-chloro-3-methyl-3,4-dihydro-2H-1,2,4-benzothiadiazine]), AMPA GluR antagonists (e.g., S-18986, and related quinolone derivatives), anticholinesterases (e.g., E-2020), Ca-antagonists (e.g., NS-649, spider venom-derived ICM peptides and analogues, and substituted 2-aminoindanes compound series), combined anticholinesterase and muscarinic AChR antagonists (e.g., PD142676), K-channel blockers (e.g., Trans-R-4-(4-methoxyphenyl-methyl) cyclohexylanine and analogues, and

margatoxin-based functional and/or structural analogues), MI muscarinic receptor agonists (e.g., Xanomeline), NMDA antagonists (e.g., certain indole derivatives, and (R-(R<sup>1</sup>,S<sup>1</sup>))- $\alpha$ -(4-hydroxyphenyl)-beta-methyl-4-(phenylmenthyl)-1-piperidinepropanol and analogues), nicotinic AChR agonists (e.g., ABT-418 [isoxazole, 3-meth-5-(1-meth-2-pyrrolidinyl)]), and the like; antiparkinson agents (e.g., ethosuximide, and the like);

10 psoriasis agents, such as 5-LO inhibitors (e.g., Wy-50295, Wy-49232, Lonapalene, RS-43179, MK-886, L-663536, ETH-615, DUP-654, Zileuton, epocarbazolin-A, and A-64077), 5-LO/CO inhibitors (e.g., BF-397, Tenidap, CP-309, and CP-66248), angiogenesis

15 inhibitors (e.g., platelet factor 4), anticancer antibiotic (e.g., AGM-1470, and TNP-470), anti-inflammatory cytochrome P450 oxidoreductase inhibitors (e.g., DuP-630, and DuP-983), antiproliferative compounds (e.g., Zyn-Linker),

20 arachidonic acid analogues (e.g., CD581, and CD554), arachidonic acid antagonists (e.g., Lonapalene, RS-43179, triamcinolone acetonide with penetration enhancer Azone, betamethasone dipropionate steroid wipe, G-202, Halobetasol

25 propionate, ultravate, Halometasone, C-48401-Ba, and Sicorten), beta-glucan receptor antagonists, betamethasone steroid wipes, calcium metabolic moderators (e.g., Tacalcitol, Bonealfa, TV-02 ointment, Ro-23-6474, KH-1060, Calcipotriol, BMS-181161, BMY-30434, Dovonex, and Divonex), CD4

30 binding inhibitors (e.g., PIC 060), cell adhesion compounds (e.g., CY-726, VCAM-1, ELAM-1, and ICAM), cell adhesion inhibitors (e.g., selectin inhibitor, GM-1930), cellular aging inhibitors

35 (e.g., Factor X), corticosteroids (e.g., Halobetasol propionate, ultravate, Halometasone, C-48401-Ba, and Sicorten), cyclosporin analogues

(e.g., IMM-125), dihydrofolate reductase inhibitors (e.g., G-301, dichlorobenzoprim, methotrexate, and methotrexate in microsphere delivery system), E-selectin inhibitors (e.g., ISIS 4730), endogenous active form of vitamin D<sub>3</sub> (e.g., Calcitriol, and Du- 026325), fibroblast growth factor antagonists (e.g., Saporin mitotoxin, and Steno-Stat), fumagillin analogues (e.g., AGM-1470, and TNP-470), G-proteins and signal transduction compounds (e.g., CPC-A), gel formulations for acne (e.g., nicotinamide, N-547, and Papulex), growth hormone antagonists (e.g., Octreotide, Sandostatin, Lanreotide, angiopeptin, BIM-23014, and Somatuline), humanized antibodies (e.g., anti-CD4 antibody), hydroorotate dehydrogenase inhibitors (e.g., Brequinar sodium, bipenquinatate, and DuP-785), ICAM-1 inhibitors (e.g., ISIS 939), IL-1 and other cytokine inhibitors (e.g., Septanil), IL-1 converting enzyme inhibitors, IL-1 receptor antagonists (e.g., Antril), IL-2 antagonists (e.g., Tacrolimus, Prograf, and FK-506), IL-2 receptor-targeted fusion toxins (DAB389IL-2), IL-8 receptors, immunostimulants (e.g., Thymopentin, and Timunox), immunosuppressants (e.g., XomaZyme-CD5 Plus, cyclosporine, Sandimmune, SR-31747, anti-CD11, 18 MAb, Tacrolimus, Prograf, FK-506, and FK-507), immunosuppressive agents targeting FK506 (e.g., immunophilins, VX-10367, and VX-10428), immunotoxins MAb directed against CD antigen (e.g., XomaZyme-CD5 Plus), leukotriene antagonists (e.g., Sch-40120, Wy-50295, and Wy-49232), leukotriene B<sub>4</sub> antagonists (e.g., SC-41930, SC-50605, SC-48928, ONO-4057, LB-457, LY-255283, LY-177455, LY-223982, LY-223980, and LY- 255253), leukotriene synthesis inhibitors

(MK-886, and L-663536), lipase clearing factor inhibitors (e.g., 1-docosanol, and lidakol), lipid encapsulated reducing agent (e.g., Dithranol), liposomal gel (e.g., Dithranol), LO inhibitors (e.g., CD581, CD554, Masoprocol, and Actinex), lithium succinate ointments (e.g., lithium salts, and Efalith), LO/CO inhibitors (e.g., P-8892, P-8977, CHX-108, and FPL-62064), membrane integrity agonists (e.g., lithium salts, and Efalith), microtubule inhibitors (e.g., Posophyllotoxin-containing compound, and Psorex), octapeptide somatostatin analogues (e.g., Lanreotide, angiopeptin, BIM-23014, and Somatuline), oligonucleotides (e.g., ISIS 4730, ISIS 3801, ISIS 1939, and IL-1 inhibitors), peptide agonists (e.g., octapeptide, and peptide T), PKC inhibitors, phospholipase A2 compounds, phospholipase D compounds, photodynamic anticancer agents (e.g., 5-aminolevulinic acid, and 5-ALA), photodynamic therapies (e.g., benzoporphyrin derivative, synthetic chlorins, synthetic porphyrins, and EF-9), photosensitizer (e.g., Porfirmer sodium), PKC inhibitors (e.g., Safingol, and Kynac), platelet activating factor antagonists (e.g., TCV-309), platelet aggregation inhibitors (e.g., CPC-A), prodrug NSAIDs (e.g., G-201), prostaglandin agonist (e.g., eicosapentaenoic acid + gamma-linolenic acid combination, and Efamol Marine), protein inhibitors (e.g., SPC-103600, and SPC-101210), protein kinase C (PKC) inhibitors (e.g., Ro-31-7549, Ro-31-8161, and Ro-31-8220), protein synthesis antagonists (e.g., Calcitriol, Du-026325, LG-1069, LG-1064, AGN-190168, Namirotenene, and CBS-211A), purine nucleoside phosphorylase inhibitors (e.g., BCX-34), radical formation agonists (e.g., benzoporphyrin

derivative), recombinant antileukoproteinasases (e.g., ALP-242), retinoids (e.g., BMY-30123, LG-1069, and LG-1064), retinoid derivatives (e.g., AGN-190168), rapamycin binding proteins (FKBP) (e.g., immunophilins, VX-10367, and VX-10428), second generation monoaromatic retinoids (e.g., Acitretin, and Neotigason), soluble IL-1, IL-4 and IL-7 receptors, somatostatin and somatostatin analogues (e.g., Octreotide, and Sandostatin), steroids, (e.g., AGN-191743), streptomyces anulatus isolates (e.g., epocarbazolin-A), superoxide dismutase (e.g., EC-SOD-B), thymidylate synthase inhibitors (e.g., AG-85, MPI-5002, 5-FU in biodegradable gel-like matrix, 5-FU and epinephrine in biodegradable gel-like matrix, and AccuSite), topical formulations (e.g., P-0751, and P-0802), transglutaminase inhibitors, tyrphostin EGF receptor kinase blockers (e.g., AG-18, and AG-555), VCAM-1 inhibitors (e.g., ISIS 3801), vitamin D analogues (e.g., Ro-23-6474, KH-1060, Calcipotriol, BMS-181161, BMY-30434, Dovonex, and Divonex), vitamin D<sub>3</sub> analogues (e.g., Tacalcitol, Bonealfa, TV-02 ointment), and vitamin D<sub>3</sub> derivatives (e.g., 1,2-diOH-vitamin D<sub>3</sub>), and the like;

diabetes agents, such as ACE inhibitors (e.g., captopril), amylin, amylin agonists and antagonists (e.g., Normylin™, AC137, GC747, AC253, and AC625), autoimmune compounds (e.g., AI-401), capsaicins (e.g., Zostrix-HP), cell regulators (e.g., protein kinase C inhibitors, and Balanol), domperidones (e.g., Motilium®), fluvastatins (e.g., Lescol), FOX 988, fusion toxins (e.g., DAB<sub>389</sub>IL-2, and DAB<sub>486</sub>IL-2), gene therapies (e.g., Transkaryotic Therapies), glucagons (e.g., recombinant yeast glucagon), IL-10 compounds,

5 iloprost, immunosuppressives (e.g., tacrolimus, Prograf, and FK-506), proinsulin, insulin and insulin analogs (e.g., AI-401, Nu-Insulin compounds, Humulin, Iletin, Humalog™, LYS-Pro, and Amaryl), insulin-like growth factors (e.g., Chiron/Ciba-Geigy compounds, Fujisawa compounds, and Genetech compounds), insulinotropins (e.g., Pfizer/Scios Nova compounds), nerve growth factors (e.g., Genentech compounds), oral  
10 hypoglycemics (e.g., AS-6, glimepiride, Amaryl, CL 316,243, acarbose, miglitol, recombinant yeast glucagon, GlucaGen™, NovoNorm™, glipizide, insulinotropin, and CI-991/CS-045), platelet-derived growth factors (e.g., Zymo Genetics/Novo Nordisk compounds), sulfonylureas (e.g., tolbutamide, acetohexamide, tolazamide, and chlorpropamide), T cell approaches (e.g., anergize, Anergix™, Procept compounds, and T cell Sciences compounds), and tolrestats (e.g.,  
15 Alredase®, and ARI-509), activin, somatostatin, and the like;

stroke agents, such as 5-HT antagonists (e.g., Piperazine derivative), 5-HT reuptake inhibitors (e.g., Milnacipran, and Dalcipran), 5-HT 1A agonists  
25 (e.g., SR-57746A, and SR-57746), 5-HT 3 agonists (e.g., SR-57227), 5-HT 4 antagonists, 5-lipoxygenase inhibitors (e.g., low MW dual 5-lipoxygenase and PAF inhibitor CMI-392), ACh agonists (e.g., Pramiracetam, Choline-L-alfoscerate, L-alpha-glycerylphosphoryl-choline, and Delecit), adenosine agonists (e.g., GP-1-4683, ARA-100, and arasine analogs), adenosine A1 receptor agonists (e.g., Azaisotere, 2-chloro-N-[4 (phenylthio)-1-piperidinyl]  
30 adenosine, and 2120136), adenosine reuptake inhibitors (e.g., Diphenyloxazole derivatives), adrenergic transmitter re-uptake inhibitors

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(e.g., Bifemelane, E-0687, MCI-2016, Alnert, and Celeport), aldose reductase inhibitors (e.g., Spiro-3' pyrroline derivatives), alpha antagonists (e.g., Drotaverine acephyllinate, and Depogen), alpha 2 agonists (e.g., SNAP-5083, SNAP-5608, and SNAP-5682), AMPA receptor agonists (e.g., heterocyclic compound SYM-1207, and heterocyclic compound SYM-1252), AMPA receptor antagonists (e.g., LY-293558, and LY-215490), Ancrod/Arvin, aspirin, benzothiazoles (e.g., Lubeluzole, and R87926), benzodiazepine receptor antagonists (e.g., 3-oxadiazolyl-1,6-naphthyridine derivatives, Tetracyclic imidazodiazepineseries imidazenil, FID-02-023, and Ro-23-1412), blood substitutes, bradykinin antagonists (e.g., CP-0127, Bradycor, and Septicor), C5a release inhibitors (e.g., protein derivative CMI-46000), calcium antagonists (e.g., Lemildipine, NB-818, NPK-1886, Trimetazidine derivative, Iomerizine KP-2796, Diltiazem analog clentiazem maleate, and TA-3090), calcium channel antagonists (e.g., nitrendipine-like compound diperdipine, YS-201, U-92032, Diltiazem derivative, 1058, SM-6586, KP-840, F-0401, D-31-D, Tetrahydronaphthalene derivatives, fasudil, AT-877, H-7, HA-1044, HA-1077, Eril, darodipine, dazodipine, PY-108-068, Plimo, Dihydropyridine, AE 0047, GJ-0956, Lacidipine, GR-43659, GR-43659X, GX-1048, S-312-d, S-312, S-830312, Nilvadipine, and FK-235), calpain inhibitors (e.g., AK-275, and CX-275), carnitine palmitoyl-transferase inhibitors, carvedilol, cerebral calcium antagonist vasodilators (e.g., Nimodipine, and Nimotop), cholinesterase inhibitors (e.g., indole and indazole derivatives, and Tacrine analog), complement factor inhibitors (e.g., TK9C, protein derivative

TP16, compinact A, compinact C, Factor D inhibitors, and soluble, recombinant MCP-based complement inhibitors), complement inhibitors (e.g., sCRI/BRL-55730, and YM-203), coronary vasodilators (e.g., Nicorandil, RP-46417, SG-75, and Adancor), CPC-111, cytidyl diphosphocholine/citicholines, cytokines (e.g., NBI-117), Dexanabiol, dopamine agonists, EAA receptors, endothelin antagonists (e.g., SB 209670), endothelin receptor antagonists, excitatory amino acid agonists (e.g., acylated polyamine analogs, and N-(4-hydroxyphenylpropionyl)-spermine analog), excitatory amino acid antagonists (e.g., Tryptophan, 4,6-disubstituted stroke & kynurenine derivatives, NPC-17742, CPC-701, and CPC-702), glutamate antagonists (e.g., Kainate quisqualate NNC-07-9202, NPC-17742, small molecule CNS-1237, NS-257, NS-072, BW-619C, CGS 19755, Riluzole, PK-26124, and RP 54274), glutamate receptor antagonists (e.g., Araxin compounds, Quinoxaline derivative, YM-90K, and YM-900), glycine antagonists, glycine NMDA agonists (e.g., 3-hydroxy-2,5-dioxo-1H-benz[b]azepines), glycine NMDA associated antagonists (e.g., 5,6-dihydro-1H-pyrrolo [1,2,3-de] quinoxaline-2,3-diones, Strychnine-insensitive glycine binding site of NMDA receptor L-687414, Glystasins, ACEA-2011, ACEA-3031, AC-1021, ACPC, and eliprodil), growth factor antagonists (e.g., non-peptide indolocarbazole neutrophilic molecules, and CEP-075), GPIIb/IIIa antagonists (e.g., Peptide C68-22), hemorheological agents (e.g., Drotaverine acephyllinate, and Depogen), heparin, hydroxyl radical formation inhibitors (e.g., homopiperazine derivative K-7259), hypocalcemic agents (e.g., calcitonin peptide, related to

hCGRP peptide), hypothermic agents/BMY-20862, ICAM-1 compounds (e.g., Enlimomab), immunosuppressants (e.g., small molecule compounds, and NBI-117), integrin general antagonists (e.g., monoclonal antibody AN-100225, and monoclonal antibody AN-100226), Interleukin-1 antagonists (e.g., cyclic nitrones), iron-dependent lipid peroxidation inhibitors (e.g., 2-(amino-methyl) chromans), lactic acid accumulation/inhibitors (e.g., small molecule CPC-211), Leukotriene B4 antagonists (e.g., Ebselen, DR-3305, PZ-25, PZ-51, RP 60931, and RP 61605), lipid peroxidase inhibitors (e.g., Idebenone, and Avan), low molecular weight small molecules, methyltransferase stimulants (e.g., 4-methyl benzenesulfonate, ademetionine sulfate tosilate, FO-156, and Ceritan), monoamine oxidase B inhibitors (e.g., MD-280040, MD-200243, MD-280080, Lazabemide, and Ro-19-6327), MS-153, MS-424,  $/\text{Na}^+/\text{H}^+ \text{Na}^+/\text{Li}^+$  exchange inhibitors (e.g., Pyrazine derivatives), nadroparin (e.g., Fraxiparin), nafronyl/naftidrofuryl (e.g., Praxilene), nerve growth factor agonists (e.g., small molecule compounds, CNTF, BDNF, 2.5S NGF, monosialoganglioside GM1, and Sigen/Sygen), neuronal calcium channel blockers (e.g., CPC-304, and CPC-317), neuronal differentiation compounds (e.g., F-spondin), neuropeptide agonists (e.g., Neurotrophic Peptide Trofexin), neutrophil inhibitory factors (e.g., small molecule compounds), nitric oxide agonists (e.g., hydroxy derivative N-3393, hydroxy derivative N-3398, nicorandil, and Therapicon), nitric oxide antagonists, NMDA antagonists (e.g., Spiroisoindoles/dizocilpine derivatives, Oxindole compound, CP-112116, LY-104658, LY-235959, FR-115427, Sialic acid derivative,

5 N-palmitoyl-Betaethylglycoside neuraminic acid, ND-37, Ro-01-6794, 706, Dextrorphan, Ifenprodil analogue eliprodil, SL-82.0715, Lipophilic molecules, HU-211, Remacemide, 934-423, 12495, 12859, 12942AA, Selfotel, CGS-19755, SDZ-EAA-494, CGP-40116, CGP-37849, CGP-39551, and CGP-43487),

10 NMDA antagonist-partial agonists (e.g., Conantokin G peptide SYM-1010), NMDA channel blockers (e.g., Aptiganel, CERESTAT, and CNS 1102), NMDA receptor antagonists, NMDA receptor subtypes (e.g., Kainate quisqua-late NNC-07-9202), non-competitive NMDA antagonists (e.g., FPL-15896), non-ionic copolymer RheothRx, nootropic/acetylcholine agonists (e.g.,

15 Oxiracetam, CT-848, and Neuractiv), norepinephrine inhibitors (e.g., Midalci-pran), N-type calcium channel antagonists (e.g., NS-626, and NS-638), opioid antagonists (e.g., Nalmefene, nalmetrene, JF-1, ORF-11676, Cervene, and

20 Incystene), opioid kappa receptor agonists (e.g., acrylacetamide enadoline, and CI-997), organoselenims (e.g., Ebselen, DR-3305, PZ-25, PZ-51, RP 60931, and RP 61605), oxygen scavengers (e.g., Tirilazad mesylate, Lazaroids, and

25 Freedox), PA2 inhibitors (e.g., phospholipase A2 inhibitor), PAF antagonists (e.g., nupafant, and BB-2113), partial glycine NMDA agonists (e.g., ACPC), peptide/ GPIIb/IIIa antagonists (e.g., Integrelin), peptidic neuron-specific calcium

30 channel antagonists (e.g., SNX-111), phosphodiesterase inhibitors (e.g., Xanthine derivatives, propentofylline, Hoe-285, and Hextol), phospholipase A2 inhibitors (e.g., small organic molecule CEP-217), plasminogen activators (e.g., r-ProUK (recombinant pro-urokinase),

35 platelet-activating factor antagonists (e.g., UK-74505), platelet adhesion inhibitors (e.g.,

Peptide), platelet aggregation antagonists (e.g., cilostazol, peptide agents, GPHb-IIIA inhibitor, and TP-9201), platelet aggregation inhibitors (e.g., Diaminoalkanoic acid derivatives),  
5 potassium channel agonists (e.g., Nicorandil, RP-46417, SG-75, and Adancor), prolyl endopeptidase (PEP) inhibitors (e.g., JTP-4819), protein kinase C inhibitors (e.g., monosialoganglioside derivative Liga-20),  
10 proteolytic enzyme inhibitors (e.g., Protease nexin-1, Incyte, PN-1, PN-2, Nafamostat, FUT-175, Duthan, and Futhan), pyrimidine derivatives, Quinolizine derivatives (e.g., KF-17329, and KF-19863), radical formation antagonists (e.g.,  
15 EPC-K1), recombinant tissue plasminogen activators (e.g., alteplase, and Activase), Schwann cell derived molecules/promoters, sigma antagonists (e.g., Sigma ligand), sigma receptor antagonists (e.g., tetrahydropyridinyl-  
20 isoxazolines and isoxazoles PD-144418), sodium/calcium channel modulators (e.g., Lifarizine, and RS-87476), sodium channel antagonists, streptokinase (e.g., Streptase), substituted guanadine (e.g., small molecule  
25 CNS-1237), superoxide dismutase stimulants (e.g., PEG conjugated enzyme superoxide dismutase/Dismutec, and PEG-SOD), thrombin inhibitors, (e.g., non-peptide), thromboxane synthase inhibitors (e.g., Linotroban, and  
30 HN-11500), thyrotropin-releasing hormone agonists (e.g., TRH agonists, Protirelin analogthymoliberin, and RX-77368), ticlopidine (e.g., Ticlid), TJ-8007, TRH agonists (e.g., Thyrotropin releasing hormones, and JTP-2942),  
35 trilazard, urokinase (e.g., Abbokinase), w-conopeptide (e.g., SNX-111), and warfarin (e.g., Coumadin), and the like;

- agents useful for the treatment of carcinomas (e.g.,  
adriamycin, taxol, interleukin-1, interleukin-2  
(especially useful for treatment of renal  
carcinoma), and the like, as well as leuprolide  
5 acetate, LHRH analogs (such as nafarelin  
acetate), and the like, which are especially  
useful for the treatment of prostatic carcinoma),  
agents useful for the treatment of endometriosis (e.g.,  
LHRH analogs),  
10 agents useful for the treatment of uterine contraction  
(e.g., oxytocin),  
agents useful for the treatment of diuresis (e.g.,  
vasopressin),  
agents useful for the treatment of cystic fibrosis (e.g.,  
15 Dnase (i.e., deoxyribonuclease), SLPI, and the  
like),  
agents useful for the treatment of neutropenia (e.g.,  
GCSF),  
agents useful for the treatment of lung cancer (e.g., beta  
20 1-interferon),  
agents useful for the treatment of respiratory disorders  
(e.g., superoxide dismutase),  
agents useful for the treatment of ischemia/reperfusion  
injury (e.g., selectin inhibitors, Irfl, and the  
25 like);  
nitric oxide synthase inhibitors (e.g.,  
N<sup>4</sup>-methyl-L-arginine, aminoguanidine,  
N<sup>6</sup>-(iminoethyl)-L-ornithine, thiocitrulline and  
other citrulline derivatives, N<sup>4</sup>-nitro-L-  
30 arginine, N<sup>4</sup>-nitro-L-arginine methyl ester,  
N<sup>4</sup>-amino-L-arginine, and other arginine  
derivatives, isothiourea and its derivatives, and  
the like,  
as well as a variety of other agents, such as acyclovir,  
35 alendronate sodium, amlodipine, ampicillin, azelaic acid,  
azithromycin, beclomethasone, betamethasone, bicalutamide,  
buspirone, carisoprodol, carvedilol, cefaclor, cefadroxil,

cefixime, cefprozil, ceftibuten, cefuroxime axetil, cephalixin, cetirizine hydrochloride, cimetidine, ciprofloxacin, cisapride, clarithromycin, clavulanate, clonazepam, clotrimazole, codeine, conjugated estrogens, 5 cyclobenzaprine, desogestrel, dexrazoxane, diazepam, dicyclomine HCl, digoxin, diltiazem, dirithromycin, doxazosin, doxycycline, enalapril, erythromycin, erythromycin base, erythromycin stearate, estradiol, ethinyl estradiol, ethynodiol diacetate, etodolac, 10 famotidine, fluconazole, fluoxetine, fluvastatin, furosemide, gemfibrozil, glipizide, glyburide, guaifenesin, hydrochlorothiazide, hydrocodone, hydrocortisone, ibuprofen, ibutilide fumarate, indapamide, insulin, ipratropium bromide, ketoconazole, ketoprofen, ketorolac 15 tromethamine, lamivudine, lansoprazole, levonorgestrel, levothyroxine, lisinopril, loracarbef, loratidine, lorazepam, losartan potassium, lovastatin, medroxyprogesterone, methylphenidate, methylprednisolone, metoprolol, metoprolol tartrate, moexipril hydrochloride, 20 mometasone furoate, mupirocin, mycophenolate mofetil, nabumetone, nalmefene hydrochloride, naproxen, neomycin, nifedipine, nisoldipine, nitrofurantoin, nizatidine, norethindrone, norgestrel, nortriptyline, ofloxacin, omeprazole, oxaprozin, oxycodone, paroxetine, penicillin, 25 pentoxifylline, phenylpropanolamine, phenytoin, polymyxin, porfimer sodium, potassium chloride, pravastatin, prednisone, promethazine, propoxyphene, pseudoephedrine, quinapril, ramipril, ranitidine, riluzole, salmeterol, saquinavir mesylate, sertraline, sevoflurane, simvastatin, 30 sucralfate, sulfamethoxazole, sumatriptan, temazepam, terazosin, terconazole, terfenadine, tetracycline, theophylline, timolol, tramadol, tramadol hydrochloride, tretinoin, triamcinolone acetonide, triamterene, trimethoprim, valproic acid, venlafaxine, verapamil, 35 wafarin, zolpidem, and the like.

The nitric oxide scavenging component (e.g., dithiocarbamate component) and the pharmacologically active agent of invention conjugates can be covalently attached employing a variety of linkages, e.g., ester linkages, 5 disulfide linkages, amide linkages, ether linkages, thioether linkages, imide linkages, sulfate ester linkages, sulfonate ester linkages, phosphate ester linkages, carbonate linkages, O-glycosidic linkages, S-glycosidic linkages, and the like. Such linkages can be accomplished 10 using standard synthetic techniques as are well known by those of skill in the art, either by direct reaction of the starting materials, or by incorporating a suitable functional group on the starting material, followed by coupling of the reactants.

15 In accordance with another embodiment of the present invention, there are provided methods for the preparation of protected forms of pharmacologically active agents, said method comprising covalently attaching a suitable nitric oxide scavenger (e.g., dithiocarbamate) to 20 said pharmacologically active agent. The resulting conjugate provides a latent form of the pharmacologically active agent, releasing the biological activity thereof only when the covalent bond linking the nitric oxide scavenger (e.g., dithiocarbamate) to said pharmacologically 25 active agent is cleaved (e.g., by an esterase, amidase or other suitable enzyme). Cleavage of the covalent bond linking the dithiocarbamate to said pharmacologically active agent also releases free dithiocarbamate, which provides effective nitric oxide scavenging activity 30 directly at the site where nitric oxide production is commonly induced as a result of the disease state being treated and/or as a result of the treatment itself.

In accordance with yet another embodiment of the present invention, there are provided methods for reducing 35 the side effects induced by administration of



pharmacologically active agent(s) to a subject, said method comprising covalently attaching a suitable nitric oxide scavenger (e.g., dithiocarbamate) to said pharmacologically active agent(s) prior to administration to said subject.

5           In accordance with still another embodiment of the present invention, there are provided methods for enhancing the effectiveness of pharmacologically active agent(s), said method comprising covalently attaching a suitable nitric oxide scavenger (e.g., a dithiocarbamate)  
10 to said pharmacologically active agent.

          In accordance with a still further embodiment of the present invention, there are provided improved methods for the administration of pharmacologically active agent(s) to a subject for the treatment of a pathological condition,  
15 the improvement comprising covalently attaching a dithiocarbamate to said pharmacologically active agent prior to administration of said pharmacologically active agent to said subject.

          Those of skill in the art recognize that the  
20 nitric oxide scavenger-containing scavengers described herein can be delivered in a variety of ways, such as, for example, orally, intravenously, subcutaneously, parenterally, rectally, by inhalation, and the like.

          Depending on the mode of delivery employed, the  
25 nitric oxide scavengers contemplated for use herein can be delivered in a variety of pharmaceutically acceptable forms. For example, the scavenger can be delivered in the form of a solid, solution, emulsion, dispersion, micelle, liposome, and the like.

30           Thus, in accordance with still another embodiment of the present invention, there are provided physiologically active composition(s) comprising

compound(s) having the structure I in a suitable vehicle rendering said compound(s) amenable to oral delivery, transdermal delivery, intravenous delivery, intramuscular delivery, topical delivery, nasal delivery, and the like.

5                   Pharmaceutical compositions of the present invention can be used in the form of a solid, a solution, an emulsion, a dispersion, a micelle, a liposome, and the like, wherein the resulting composition contains one or more of the compounds of the present invention, as an  
10 active ingredient, in admixture with an organic or inorganic carrier or excipient suitable for enteral or parenteral applications. The active ingredient may be compounded, for example, with the usual non-toxic, pharmaceutically acceptable carriers for tablets, pellets,  
15 capsules, suppositories, solutions, emulsions, suspensions, and any other form suitable for use. The carriers which can be used include glucose, lactose, gum acacia, gelatin, mannitol, starch paste, magnesium trisilicate, talc, corn starch, keratin, colloidal silica, potato starch, urea,  
20 medium chain length triglycerides, dextrans, and other carriers suitable for use in manufacturing preparations, in solid, semisolid, or liquid form. In addition auxiliary, stabilizing, thickening and coloring agents and perfumes may be used. The active compound(s) (e.g., one or more  
25 pharmacologically active agents, covalently bound to a dithiocarbamate of structure I) is(are) included in the pharmaceutical composition in an amount sufficient to produce the desired effect upon the process or disease condition.

30                   Pharmaceutical compositions containing the active ingredient may be in a form suitable for oral use, for example, as tablets, troches, lozenges, aqueous or oily suspensions, dispersible powders or granules, emulsions, hard or soft capsules, or syrups or elixirs. Compositions  
35 intended for oral use may be prepared according to any

method known to the art for the manufacture of pharmaceutical compositions and such compositions may contain one or more agents selected from the group consisting of a sweetening agent such as sucrose, lactose, or saccharin, flavoring agents such as peppermint, oil of wintergreen or cherry, coloring agents and preserving agents in order to provide pharmaceutically elegant and palatable preparations. Tablets containing the active ingredient in admixture with non-toxic pharmaceutically acceptable excipients may also be manufactured by known methods. The excipients used may be, for example, (1) inert diluents such as calcium carbonate, lactose, calcium phosphate or sodium phosphate; (2) granulating and disintegrating agents such as corn starch, potato starch or alginic acid; (3) binding agents such as gum tragacanth, corn starch, gelatin or acacia, and (4) lubricating agents such as magnesium stearate, stearic acid or talc. The tablets may be uncoated or they may be coated by known techniques to delay disintegration and absorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a time delay material such as glyceryl monostearate or glyceryl distearate may be employed. They may also be coated by the techniques described in the U.S. Pat. Nos. 4,256,108; 4,160,452; and 4,265,874, to form osmotic therapeutic tablets for controlled release.

In some cases, formulations for oral use may be in the form of hard gelatin capsules wherein the active ingredient is mixed with an inert solid diluent, for example, calcium carbonate, calcium phosphate or kaolin. They may also be in the form of soft gelatin capsules wherein the active ingredient is mixed with water or an oil medium, for example, peanut oil, liquid paraffin, or olive oil.

The pharmaceutical compositions may be in the form of a sterile injectable suspension. This suspension may be formulated according to known methods using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally-acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil may be employed including synthetic mono- or diglycerides, fatty acids (including oleic acid), naturally occurring vegetable oils like sesame oil, coconut oil, peanut oil, cottonseed oil, etc., or synthetic fatty vehicles like ethyl oleate or the like. Buffers, preservatives, antioxidants, and the like can be incorporated as required.

Compounds contemplated for use in the practice of the present invention may also be administered in the form of suppositories for rectal administration of the drug. These compositions may be prepared by mixing the drug with a suitable non-irritating excipient, such as cocoa butter, synthetic glyceride esters of polyethylene glycols, which are solid at ordinary temperatures, but liquify and/or dissolve in the rectal cavity to release the drug.

Since individual subjects may present a wide variation in severity of symptoms and each drug has its unique therapeutic characteristics, the precise mode of administration and dosage employed for each subject is left to the discretion of the practitioner.

In general, the dosage of nitric oxide scavenger-containing conjugate of the invention employed as described herein falls in the range of about 0.01 mmoles/kg body weight of the subject/hour up to about 0.5 mmoles/kg/hr. Typical daily doses, in general, lie within the range of

from about 10  $\mu$ g up to about 100 mg per kg body weight, and, preferably within the range of from 50  $\mu$ g to 10 mg per kg body weight and can be administered up to four times daily. The daily IV dose lies within the range of from  
5 about 1  $\mu$ g to about 100 mg per kg body weight, and, preferably, within the range of from 10  $\mu$ g to 10 mg per kg body weight.

In accordance with yet another embodiment of the present invention, there are provided improved methods for  
10 the treatment of a subject suffering from a pathological condition by administration thereto of pharmacologically active agent(s), the improvement comprising covalently attaching a dithiocarbamate to said pharmacologically active agent prior to administration thereof to said  
15 subject.

Thus, invention method for the treatment of a subject afflicted with a pathological condition comprises administering to a subject an effective amount of a modified pharmacologically active agent,  
20 wherein said pharmacologically active agent is effective for treatment of said condition, and  
wherein said pharmacologically active agent has been modified by the covalent attachment thereto of a dithiocarbamate.

25 The invention will now be described in greater detail by reference to the following non-limiting examples.

#### Example 1

##### Preparation of the ester conjugate of pyrrolidinol and ibuprofen

30 To 200 ml of methylene chloride in a 500-ml reaction vessel was added 24 grams of ibuprofen ( $\alpha$ -methyl-4-(2-methylpropyl)benzene-acetic acid), 10 grams of 2-pyrrolidinol and 0.5 grams of a suitable coupling agent,

e.g., dicyclohexylcarbodiimide. The reaction proceeds at room temperature for 1 to 3 hours with stirring. The ester conjugate is isolated and purified with a 60-70% yield.

#### Example 2

5     Conversion of the ester conjugate of pyrrolidinol  
          and ibuprofen to the ester conjugate of  
          pyrrolidinol dithiocarbamate and ibuprofen

To 100 ml of methanol in a 500-ml reaction vessel was added 10 grams of the ester conjugate obtained from  
10   Example 1. An aqueous NaOH solution (6.9 grams in 10 ml water) is added dropwise to the reaction mixture at 4°C. The reaction is allowed to proceed for one additional hour at 4°C. A solution mixture of carbon disulfide (5 ml) and ethanol (15 ml) is added dropwise to the above reaction  
15   mixture with slow stirring at 4°C. The final product is isolated and purified with a yield of about 70%.

#### Example 3

Preparation of the ester conjugate of  
          L-proline and adriamycin

20           To 200 ml of methylene chloride in a 500-ml reaction vessel was added 47.2 grams of adriamycin, 10 grams of L-proline and 0.5 grams of any suitable coupling agent, e.g., dicyclohexylcarbodiimide. The reaction is allowed to proceed at room temperature for 1 to 3 hours  
25   with stirring. The ester conjugate is isolated and purified with about 70% yield.

#### Example 4

30           Conversion of the ester conjugate of  
          L-proline and adriamycin to the ester conjugate of  
          L-proline dithiocarbamate and adriamycin

To 100 ml of methanol in a 500-ml reaction vessel was added 10 grams of the ester conjugate obtained from Example 3. An aqueous NaOH solution (6.9 grams in 10 ml)

water is added dropwise to the reaction mixture at 4°C. The reaction is allowed to proceed for one additional hour at 4°C. A solution mixture of carbon disulfide (5 ml) and ethanol (15 ml) is added dropwise to the above reaction mixture with slow stirring at 4°C. The final product is isolated and purified with a yield of about 70%.

#### Example 5

10      Evaluation of the effects of the conjugate  
         of pyrrolidinol dithiocarbamate and ibuprofen (PDI)  
         on the acute gastric mucosal injury

Wistar rats (200-250 grams, male) are fasted overnight but allowed free access to water. Ten rats in each group are given ibuprofen or PDI orally at doses of 10, 20 or 50 mg/kg. The rats are sacrificed five hours later and visible gastric damage is assessed by examining under microscope and histological evaluation.

#### Example 6

20      Evaluation of the effects of the conjugate  
         of pyrrolidinol dithiocarbamate and ibuprofen (PDI)  
         on chronic gastric ulcer

White New Zealand rabbits (male, about 1 kg) are given subcutaneously ibuprofen or PDI at a dose of 30 mg/kg for every 12 hours. The animals are sacrificed on day 4 (after the 7th dose) and the visible ulcers in the stomach are examined and measured with calipers. The tissue samples are fixed in neutral buffered formalin and processed for histological evaluation.

#### Example 7

30      Evaluation on the anti-inflammatory effects  
         of the conjugate of pyrrolidinol dithiocarbamate  
         and ibuprofen (PDI)

Wistar rats (male, 200-250 g) are fasted overnight but allowed to free access to drinking water.

Ibuprofen or PDI is given orally at a dose of 1, 10, or 30 mg/kg (6 animals each group). After one hour, the rats are anesthetized and 0.1 ml of lambda carrageenan (0.1% solution) is injected into the right hind foot pad. The volume of the pad is measured by hydroplethysmometry every hour for the next five hours.

#### Example 8

Evaluation of the effects of the conjugate of pyrrolidinol dithiocarbamate and ibuprofen (PDI) on prostaglandin synthesis

Wistar rats (male, 200-250 g) are fasted overnight but allowed free access to drinking water. The rats are anesthetized and their backs are shaved. After an incision to the back, a sponge (2.5 x 1 x 0.5 cm) soaked with 2 ml of 0.5% carrageenan is implanted. Five hours later, the rats (6 animals in each group) are given orally either ibuprofen or PDI at a dose of 30 mg/kg or vehicle control. One hour later, the rat is sacrificed and the sponge is carefully removed. The exudate is recovered from the sponge and the prostaglandin E2 level in the exudate is measured by enzyme-linked immunosorbent assay.

#### Example 9

Evaluation on the protective effects of the conjugate of L-proline dithiocarbamate and adriamycin (PDA) against adriamycin-induced cardiotoxicity

Balb/c mice (male, 20-25 g) are fed a standard diet and allowed free access to drinking water. The mice are anesthetized and the telemetry system consisting of implantable transmitters, a telemetry receiver and analog ECG adapter is implanted in the peritoneal cavity of each mouse. After surgery, the mice are allowed to recover for two weeks. The mice are given intravenously either adriamycin or PDA at a dose of 4 mg/kg through the tail vein. The treated mice are observed for two weeks. The body weight, ECG and heart rate are recorded daily. At the



end of the study, the animals are sacrificed and the hearts are processed for histological evaluation.

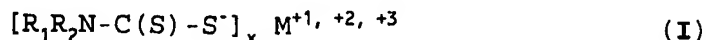
While the invention has been described in detail with reference to certain preferred embodiments thereof, it  
5 will be understood that modifications and variations are within the spirit and scope of that which is described and claimed.

That which is claimed is:

1. A compound comprising a nitric oxide scavenger covalently attached to a pharmacologically active agent.

2. A compound according to claim 1 wherein said nitric oxide scavenger is a dithiocarbamate.

3. A compound according to claim 1 wherein the dithiocarbamate component of said compound has the structure I, as follows:



5 wherein:

each of  $R_1$  and  $R_2$  is independently selected from a  $C_1$  up to  $C_{18}$  alkyl, substituted alkyl, cycloalkyl, substituted cycloalkyl, heterocyclic, substituted heterocyclic, alkenyl, substituted alkenyl, alkynyl, substituted alkynyl, aryl, substituted aryl, heteroaryl, substituted heteroaryl, alkylaryl, substituted alkylaryl, arylalkyl, substituted arylalkyl, arylalkenyl, substituted arylalkenyl, arylalkynyl, substituted arylalkynyl, aroyl, substituted aroyl, acyl, substituted acyl, or

$R_1$  and  $R_2$  can cooperate to form a 5-, 6- or 7-membered ring including N,  $R_1$  and  $R_2$ , or

$R_1$  or  $R_2$  is a divalent moiety selected from the group consisting of alkylene, substituted alkylene, oxyalkylene, substituted oxyalkylene, alkenylene and substituted alkenylene, wherein said divalent moiety serves as the same substituent for two dithiocarbamate structures, thereby linking

said structures together so as to form a bis(dithiocarbamate) species,

30 wherein  $R_1$  and/or  $R_2$  further contain a site for said covalent attachment,

$x$  is 1 or 2, and

35 M is a monovalent cation when  $x$  is 1, or M is a physiologically compatible divalent or trivalent transition metal cation when  $x$  is 2.

4. A compound according to claim 3 wherein:

5 each of  $R_1$  and  $R_2$  = a  $C_1$  up to  $C_{12}$  alkyl, substituted alkyl, alkenyl, substituted alkenyl, alkynyl or substituted alkynyl, wherein the substituents are selected from carboxyl,  $-C(O)H$ , oxyacyl, phenol, phenoxy, pyridinyl, pyrrolidinyl, amino, amido, hydroxy, nitro or sulfuryl, or

10  $R_1$  and  $R_2$  cooperate to form a 5-, 6- or 7-membered ring including N,  $R_1$  and  $R_2$ , and

$M = Fe^{+2}$  or  $Fe^{+3}$ .

5. A compound according to claim 3 wherein:

5  $R_1$  is selected from a  $C_2$  up to  $C_8$  alkyl or substituted alkyl, wherein the substituents are selected from carboxyl, acetyl, pyridinyl, pyrrolidinyl, amino, amido, hydroxy or nitro, and

$R_2$  is selected from a  $C_1$  up to  $C_6$  alkyl or substituted alkyl, or

10  $R_2$  cooperates with  $R_1$  to form a 5-, 6- or 7-membered ring including N,  $R_2$  and  $R_1$ , and

$M = Fe^{+2}$ .

6. A compound according to claim 3 wherein:  
R<sub>1</sub> is selected from a C<sub>2</sub> up to C<sub>8</sub> alkyl or substituted alkyl, wherein the substituents are selected from carboxyl, acetyl, amido or hydroxy, and  
R<sub>2</sub> is selected from a C<sub>1</sub> up to C<sub>4</sub> alkyl or substituted alkyl, or  
R<sub>2</sub> cooperates with R<sub>1</sub> to form a 5- or 6-membered ring including N, R<sub>2</sub> and R<sub>1</sub>, and  
M = Fe<sup>+2</sup>.
7. A compound according to claim 2 wherein said dithiocarbamate moiety is sarcosine dithiocarbamate, iminodiacetic acid dithiocarbamate, diethyldithiocarbamate, diisopropyldithiocarbamate, sugar-linked dithiocarbamates, pyrrolidine dithiocarbamate or proline dithiocarbamate.
8. A compound according to claim 3 wherein R<sub>1</sub> and R<sub>2</sub> of said dithiocarbamate moiety cooperate to form a 5- or 6-membered ring including N, R<sub>1</sub> and R<sub>2</sub>.
9. A compound according to claim 8 wherein said dithiocarbamate moiety is pyrrolidine dithiocarbamate or proline dithiocarbamate.
10. A compound according to claim 8 wherein said dithiocarbamate component of said compound is L-proline dithiocarbamate.
11. A compound according to claim 1 wherein said covalent linkage is selected from the group consisting of ester linkages, disulfide linkages, amide linkages, ether linkages, thioether linkages, imide linkages, sulfate ester linkages, sulfonate ester linkages, phosphate ester linkages, carbonate linkages, O-glycosidic linkages and S-glycosidic linkages.

12. A compound according to claim 1 wherein said covalent linkage is an ester linkage.

13. A compound according to claim 1 wherein said covalent linkage is a disulfide linkage.

14. A compound according to claim 1 wherein said covalent linkage is an amide linkage.

15. A compound according to claim 1 wherein said covalent linkage is a sulfonate ester linkage.

16. A compound according to claim 1 wherein said covalent linkage is a sulfate ester linkage.

17. A compound according to claim 1 wherein said covalent linkage is a phosphate ester linkage.

18. A compound according to claim 1 wherein said pharmacologically active agent is selected from NSAIDs, analgesics/antipyretics, sedatives/hypnotics, antianxiety agents, antianxiety agents, antidepressants, antipsychotic agents, antimanic agents, antiarrhythmics, antihypertensive drugs, antihistamine/antipruritic drugs, immunosuppressants, antimetabolite cytotoxics, neuroprotective agents, T cell inhibitors, antimigraine agents, antiarthritic agents, antigout agents, anticoagulants, thrombolytic agents, antifibrinolytic agents, hemorheologic agents, antiplatelet agents, anticonvulsants, agents useful for calcium regulation, antibacterial agents, antifungal agents, antiviral agents, antimicrobials, anti-infectives, bronchodilators, hormones, hypoglycemic agents, hypolipidemic agents, proteins, nucleic acids, agents useful for erythropoiesis stimulation, antiulcer/antireflux agents, antinauseants/antiemetics, septic shock agents, multiple sclerosis agents, organ transplantation agents, systemic

- 20 lupus erythematosus (SLE) agents, Alzheimer's disease agents, antiparkinson agents, psoriasis agents, diabetes agents, stroke agents, agents useful for the treatment of carcinomas, agents useful for the treatment of endometriosis, agents useful for the treatment of uterine  
25 contraction, agents useful for the treatment of diuresis, agents useful for the treatment of cystic fibrosis, agents useful for the treatment of neutropenia, agents useful for the treatment of lung cancer, agents useful for the treatment of respiratory disorders, agents useful for the  
30 treatment of ischemia/reperfusion injury, agents useful for the treatment of ophthalmic diseases, agents useful for the treatment of cardiovascular diseases, anti-inflammatory agents or antioxidants.

19. A compound according to claim 1 wherein said pharmacologically active agent is a non-steroidal antiinflammatory drug, an antihypertensive agent, an antineoplastic agent, an anti-allograft rejection agent, a  
5 neuroprotective agent, an immunosuppressive agent or an antioxidant.

20. A compound according to claim 1 wherein said pharmacologically active agent is aspirin, ibuprofen, ketoprofen, diclofenac, adriamycin, cyclosporin, FK506, LFA-1, selectin inhibitors, tissue plasminogen activator or  
5 lubeluzole.

21. A composition comprising a compound according to claim 1 in a pharmaceutically acceptable carrier therefor.

22. A composition according to claim 21 wherein said pharmaceutically acceptable carrier is selected from a solid, solution, emulsion, dispersion, micelle or liposome.

23. A composition according to claim 21 wherein said composition further comprises an enteric coating.

24. In the administration of a pharmacologically active agent to a subject for the treatment of a pathological condition, the improvement comprising covalently attaching a suitable nitric oxide scavenger to  
5 said pharmacologically active agent prior to administration of said pharmacologically active agent to said subject.

25. In the treatment of a subject suffering from a pathological condition by administration thereto of a pharmacologically active agent, the improvement comprising covalently attaching a suitable nitric oxide scavenger to  
5 said pharmacologically active agent prior to administration thereof to said subject.

26. A method for the treatment of a subject afflicted with a pathological condition, said method comprising administering to said subject an effective amount of a modified pharmacologically active agent,  
5 wherein said pharmacologically active agent is effective for treatment of said condition, and  
wherein said pharmacologically active agent has been modified by the covalent attachment thereto of a suitable nitric oxide scavenger.

27. A method for the preparation of a protected form of a pharmacologically active agent, said method comprising covalently attaching a suitable nitric oxide scavenger to said pharmacologically active agent.

28. A method for reducing the side effects induced by administration of a pharmacologically active agent to a subject, said method comprising covalently attaching a suitable nitric oxide scavenger to said  
5 pharmacologically active agent prior to administration to said subject.

29. A method for enhancing the effectiveness of a pharmacologically active agent, said method comprising covalently attaching a suitable nitric oxide scavenger to said pharmacologically active agent.



## INTERNATIONAL SEARCH REPORT

 International application No.  
PCT/US98/10295

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : Please See Extra Sheet.

US CL : 514/423, 514 : 548/565, 573

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 514/423, 514; 548/564, 573

 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS COMPUTER SEARCH 1966-TO DATE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X - Y	US 5,358,703 A (LAI) 25 October 1994, col. 9, line 51.	1-7, 11-13 ----- and 18-29
A	SCHRECK et al. Dithiocarbamates as Potent Inhibitors of Nuclear Factor KB Activation in Intact Cells. J. Exp. Med. May 1992, Vol. 175, pages 1181-1194.	1-29

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*B* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*A* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

28 JULY 1998

Date of mailing of the international search report

09 SEP 1998

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**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/US98/10295

**A. CLASSIFICATION OF SUBJECT MATTER:**  
**IPC (6):**

C07C 333/04, 333/06, 333/08; C07D 207/04, 207/30; A61K 31/27, 31/40